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AUG 20 1923

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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

OFFICES FOR ADVERTISEMENTS AND PUBLICATION, 35 & 36, BEDFORD STREET, STRAND, LONDON, W.C.2.

VOL. CXVI.—No. 3006.] *LONDON: FRIDAY, AUGUST* 10, 1923. [*Registered at the General Post Office as a Newspaper.*] [PRICE ... 1s. BY FOREIGN POST 1s. 3d.

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ON ADMIRALTY AND WAR OFFICE LISTS.
ENGINES for Torpedo Boats, Yachts, Launches.
BOILER FEED PUMPS.
See advertisement page 18.
PATENT WATER-TUBE BOILERS.
AUTOMATIC FEED REGULATORS.
And Auxiliary Machinery as supplied to the Admiralty. 2179

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OF ALL DESCRIPTIONS.
FLOATING CRANES. COAL BUNKERING VESSELS.
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Thos. Piggott & Co., Limited,
BIRMINGHAM. 1341
See Advertisement last week, page 84.

Spencer-Hopwood & Kirke
PATENT BOILERS *See Page* 74. 1293
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Tank Locomotives.
Specification and Workmanship equal to Main Line Locomotives.
R. & W. HAWTHORN, LESLIE & CO. LTD., ENGINEERS, NEWCASTLE-ON-TYNE. 1133

Cochran Boilers.
MULTITUBULAR AND CROSS-TUBE TYPES.
See page 17. 1134

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Gas Engines Inspected, Tested and Reported upon. Over 25 years' experience. Tel.: 736 and 737 Stratford. Wire: "Rapidising, London." —Great Eastern Road, Stratford, E.15. 1794

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SPECIALISTS
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SALE AND VALUATION
of 1534
PLANT AND MACHINERY
and
ENGINEERING WORKS.
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Sole Licensees in Great Britain for the manufacture of "Armco" Rust and Corrosion Resisting Iron Tubes. 817
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See Advertisement, page 69, Aug. 3.

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PASSENGER AND CARGO STEAMERS,
SHALLOW DRAFT VESSELS.
1552

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Gear Cutting.
Worm Wheels cut up to 12 ft. diam.
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The Strongest Chain in the World.
Sole Manufacturers: WELDLESS CHAINS, LTD., 50, Wellington Street, GLASGOW. 896

OIL FUEL APPLIANCES,
Systems
PRESSURE, AIR, STEAM
For Boilers of all types.
KERMODES LIMITED,
35, The Temple, Dale Street, Liverpool.
Naval Outfits a Speciality,
also for Merchant Ships, for Factories, Locomotives, and Industrial Process Furnaces of all kinds.
Supplied to the British and other Governments.
Telephone No.: Central 2632.
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Locomotives Tank Engines
designed and constructed by
MANNING, WARDLE AND COMPANY, LIMITED,
Boyne Engine Works, Leeds. Od. 2437
See their Illus. Advertisement, page 87, last week.
RAILWAY AND TRAMWAY ROLLING STOCK.
Hurst, Nelson & Co., Ltd.
THE GLASGOW ROLLING STOCK AND PLANT WORKS, MOTHERWELL. Od 3383

R. Y. Pickering & Co., Ltd.
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BUILDERS of RAILWAY CARRIAGES & WAGONS
MAKERS of WHEELS and AXLES of all kinds.
RAILWAY WAGONS FOR HIRE.
Chief Works and Offices:
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London Office: Od 8353
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Henry Butcher & Co.,
AUCTIONEERS, VALUERS AND SURVEYORS
for
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and
INDUSTRIAL PROPERTIES. 9666
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S. H. HEYWOOD & CO., LTD., 1357
REDDISH.

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Inventors Advise, Handbook and Consultations free.—KINGS PATENT AGENCY, LTD. (B. T. King, Director), 146a, Queen Victoria Street, London. 36 years' refs. 1209

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STAMPINGS,
for all Trades,
Fyfe, Lumsden Ltd.,
Eccles, Manchester.
Tel.: 884 Eccles. 1598

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—Practical Course of Instruction by Correspondence.—Address, for particulars and terms, 1463, Offices of ENGINEERING.

John Bellamy, Limited,
MILLWALL, LONDON, E. 1216
GENERAL CONSTRUCTIONAL ENGINEERS,
Boilers, Tanks, & Mooring Buoys
STILLS, PETROL TANKS, AIR RECEIVERS, STEEL CHIMNEYS, RIVETED STEAM AND VENTILATING PIPES, HOPPERS, SPECIAL WORK, REPAIRS OF ALL KINDS.

IRON & STEEL
Tubes AND Fittings
AND
Steel Plates.
STEWARTS AND LLOYDS, Ltd.
GLASGOW - BIRMINGHAM - LONDON.
See Advertisement, page 50. 1111

Peter Brotherhood Ltd.,
PETERBOROUGH.
STEAM ENGINES AND TURBINES.
GAS AND OIL ENGINES.
AIR COMPRESSORS.
REFRIGERATING PLANT. 1475
See Advertisement, page 51, Aug. 3.

Gearing for Power Transmission.
Including Machine Moulded GEAR WHEELS up to 10 feet dia.;
FLY WHEELS (rope or spur drive) up to 28 feet dia.;
IRON CASTINGS up to 15 tons each, in Loam, Dry or Green Sand;
ENGINES: "Uniflow," "Corliss" or Drop Valve.
BREAKDOWN Repairs a speciality.
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The Glasgow Railway Engineering Company,
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London Office—12, Victoria Street, S.W.
MANUFACTURERS OF
RAILWAY CARRIAGE, WAGON & TRAMWAY WHEELS & AXLES.
CARRIAGE & WAGON IRONWORK, also CAST-STEEL AXLE BOXES. 1234

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Telephone: Central 7424. Od 585

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LTD., Consulting Cement Engineers, ADVISE GENERALLY on proposed Cement Schemes FOR ENGLAND AND ABROAD. ADVICE ONLY. Highest References. Established 1890.
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(UP TO 35 TONS.)
1357
S. H. HEYWOOD & CO., LTD., REDDISH.

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Gears
Spur and Spiral.
Worms and Worm Wheels.
STORR & EVANS,
Grove Road, Hunslet, Leeds. 1573

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Diesel & Steam Engines.
1120
CARELS DIESEL & STEAM ENGINES (LONDON), LTD., Carlton House, Regent Street, London, S.W. 1. Telephone: Regent 3484.

Royles Limited,
ENGINEERS, IRLAM, MANCHESTER.
FEED WATER HEATERS, CALORIFIERS, EVAPORATORS, CONDENSERS, AIR HEATERS, } ROW'S PATENTS.
Merrill's Patent TWIN STRAINERS for Pump Suctions.
SYPHONIA STEAM TRAPS, REDUCING VALVES
High-class GUNMETAL STEAM FITTINGS.
WATER SOFTENING and FILTERING. 5733

YARROW & CO. (1922), LTD., GLASGOW.
LAND AND MARINE
YARROW BOILERS.
1553

Matthew Paul & Co., Ltd.,
LEVENFORD WORKS, Dumbarton. 1483
See Full Page Advt., page 59, July 20.

Forgings.
Walter Somers, Limited,
HALESOWEN. 7116

Taylor & Challen Presses
For Production of SHEET METAL WORK, COINAGE, CARTRIDGES AND GUNPOWDER.
Foundry, Works, and Showrooms: BIRMINGHAM.
See advert., page 10, July 20. 8195

Head, Wrightson & Co.,
LIMITED.
See Advertisement page 56. 2462

Railway Switches and Crossings.
T. SUMMERSON & SONS, LIMITED, DARLINGTON. 1313

MACHINE-CUT
D.B.S. GEARS
of every description.
1440
DAVID BROWN & SONS (Huddd.) LTD.,
Lockwood - - - - - Huddersfield.

P. & W. MacLellan, Ltd.
CLUTHA WORKS, GLASGOW.
MANUFACTURERS OF
RAILWAY CARRIAGES AND WAGONS
OF EVERY DESCRIPTION.
RAILWAY IRONWORK, BRIDGES, ROOFING, &c.
Chief Offices: 129, Trongate, Glasgow. Od 8647
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Locomotive Traversers
(ELECTRIC).
1357
S. H. HEYWOOD & CO., LTD., REDDISH.

Rosser and Russell, Ltd.,
MECHANICAL ENGINEERS.
QUEEN'S WHARF, HAMMERSMITH, W.
Undertake SPECIAL MACHINE WORK of any description.
WELL EQUIPPED SHOP.
LATHE WORK up to 10 ft. diameter.
'Phone: Hammersmith 31, 967. 9711

Centrifugals.
Pott, Cassels & Williamson,
MOTHERWELL, SCOTLAND.
939
See half-page Advertisement, page 10, Aug. 3.

The Manchester Steam Users' Association.

For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, Mount Street, Manchester.
Chief Engineer: C. E. Stromeyer, M.I.C.E.
Founded 1854 by Sir William Fairbairn.
Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 1311

University of Birmingham.

DEPARTMENT OF METALLURGY.

Professor: THOMAS TURNER, M.Sc., A.R.S.M., F.I.C.
Lecturers and Demonstrators: T. G. BAMFORD, M.Sc. HAROLD HARRIS, M.Sc. T. H. TURNER, M.Sc.

The Course of study covers three years and leads to the Degree of B.Sc. in Metallurgy. There are separate courses for Metallurgists and Metallurgical Chemists. Special attention is devoted to Iron and Steel, Copper, Brass, and Local Industries, and to preparation for Colonial and Foreign posts.
Research and other Scholarships.
For particulars apply to the REGISTRAR. B 176

The Yarrow Scholarships.

The COUNCIL of the INSTITUTION OF CIVIL ENGINEERS are PREPARED to CONSIDER APPLICATIONS for NOMINATIONS to the above SCHOLARSHIPS.

These should be submitted before the 1st October, 1923, to the SECRETARY of the Institution, at Great George Street, Westminster, S.W. 1, from whom the detailed regulations may be had on application.

The Yarrow Scholars must be British subjects who, desiring to become Engineers, lack sufficient means to enable them to pursue their practical or scientific training.

The Scholarships are of a value varying from £50-£100 per annum. B 162

Correspondence Courses for

Inst. Civil Engrs., Inst. Mech. E., London Univ. (Matric., Inter., B.Sc.), and All ENGINEERING EXAMINATIONS personally conducted by Mr. TREVOR W. PHILLIPS, B.Sc. (Honours), Assoc. M.Inst.C.E., M.R.S.I., F.R.S.A., &c. Also Day Tuition in Office. Excellent results at all Exams. Courses may commence at any time, and all Students receive individual tuition.—For full particulars apply to 8/11, Trafford Chambers, 58, South John Street, LIVERPOOL. 1295

Engineering Salesmanship

and SALES MANAGEMENT.—Write for brochure describing our special Course of training for posts of unlimited scope in this lucrative field.—DIRECTOR, Institute of Engineering Salesmanship, 333, Oxford Road, Manchester. 1587

TENDERS.

BOMBAY, BARODA & CENTRAL INDIA RAILWAY COMPANY.

The Directors are prepared to receive up to Noon on Friday, 24th August,

Tenders for the Supply of:—

PICKS, PHOWRAHS AND SHOVELS.

Tenders must be made on Forms, copies of which, with Specification, can be obtained at these Offices on payment of 10s. each (which will not be returned).

The Directors do not bind themselves to accept the lowest or any Tender.

S. G. S. YOUNG,
Secretary.

Offices: 91, Petty France, Westminster, S.W. 1.
8th August, 1923. B 307

MANCHESTER CORPORATION WATERWORKS.

HYDRAULIC POWER SUPPLY.

The Waterworks Committee invite

Tenders for One Set of

ELECTRICALLY DRIVEN HIGH-PRESSURE CENTRIFUGAL PUMPS, to deliver 1000 g.p.m. against a pressure of 1120 lbs. per square inch.

Specification and Form of Tender may be obtained on application to the Secretary, Waterworks Offices, Town Hall, Manchester, on payment of two guineas per copy, which sum will be returned on receipt of a *bona fide* Tender. Any other information respecting the work may be obtained from the Water Engineer, Town Hall, Manchester.

Tenders must be delivered not later than the 15th September, 1923.

By Order,
P. M. HEATH, Town Clerk.

Town Hall, Manchester,
7th August, 1923. B 302

SINGAPORE MUNICIPALITY.

The Municipal Commissioners of the town of Singapore invite

Tenders for the Supply,

DELIVERY and ERECTION in Singapore of the following plant:—

Section A. 5,000 kilowatt turbo-alternators and condensing plants.

Section B. Water tube boilers, draught plants and steel chimneys.

Specifications for both sections may be obtained on and after August 13th from Messrs. Preece, Cardew & Rider, 8, Queen Anne's Gate, Westminster, S.W. 1, on payment of a deposit of £2 for each section (issued in duplicate) which will be refunded on receipt of a *bona fide* Tender. Extra copies may be purchased on payment of 10/- per specification.

Sealed Tenders in duplicate endorsed "Singapore Section A" or "Section B" are to be delivered to the Agents of the Singapore Municipality, Messrs. C. C. LINDSAY & PEIRCE, 180, Hope Street, Glasgow, on or before Noon on Friday, September 7th.

The Municipal Commissioners do not undertake to accept the lowest or any Tender. B 294

METROPOLITAN BOROUGH COUNCIL OF FULHAM.

FILTRATION PLANT FOR PUBLIC BATHS.

The Council is prepared to receive

Tenders for the Supply and

ERECTION of FILTERS and PLANT at the Fulham Public Baths Specification, Tender Form and Particulars to be obtained of the Superintendent and Engineer at the Baths, Walham Green, S.W. 6.

Tenders, marked "Baths Filtration Plant," to be sent to the Town Clerk, Town Hall, Fulham, S.W.6, not later than Four p.m. on Wednesday, 19th September, 1923.

The Council does not bind itself to accept the lowest or any Tender. B 281

J. PERCY SHUTER,
Town Clerk.

Sale of Pumping

MACHINERY at HELL WATH PUMPING STATION, South Camp, Ripon, Yorkshire, by PRIVATE TENDER.

This Machinery consists of:—

Two National Oil Engines, Nos. 1990 and 1991, Horizontal Oil Engines, water cooled, T.O. type, 25 H.P., 260 Revs. per minute, complete with Driving Pulleys 40 in. by 14 in., and blow lamp and spares.

Two Rees Roturbo Pumps, Nos. 4160 and 4161, Turbines on Centrifugal System, belt driven from Engine Pulley, Head 110 ft., Revs. 1250, Galls. per hour 20,000, complete with bed plate pedestals, fast and loose pulleys and striking gear.

Six Cooling Tanks, approx. 400 gallons each.
Two Oil Tanks, " 400 " "
One Water Gauge, reading to 60 lbs. per sq. in., also feet head to 140 lbs. per sq. in.
65 ft. Steam Pipe, 4 in. diameter.
Two Sluice Valves, 6 in.
Two Guards (Wire) 8 ft. by 4 ft. and 10 ft. by 4 ft.
Two Priming Cocks 1 in.
32 ft. Chequered W.I. Plates, 15 in. wide.
23 ft. " " " 18 in. "
One No. 4 Rotary Hand Pump.
One Receiver fitted with gauge and safety valve for self-starting.
One Compressor fitted with fast and loose pulley.
36 ft. Steam Pipe, 4 in.

The plant can be inspected on site by prior arrangement with Roads and Communications Officer, R.H. Office, North Camp, Ripon.

Tenders in envelopes endorsed in left hand top corner "Tender for Machinery at Ripon," should be addressed to the COMMANDING ROYAL ENGINEER, 13, Wenlock Terrace, York, and should reach that office by Twelve Noon, on Monday, 3rd September. B 234

NORWICH CORPORATION.

THORPE POWER STATION.

The Norwich Corporation invite

Tenders for the Manufacture,

DELIVERY and ERECTION of the undermentioned Engineering Works, in connection with the above-mentioned Power Station, viz:—

(a) Two 5000 kilowatt three-phase Turbo Alternators of the impulse type, with exciters, condensers, auxiliary plant, etc.
(b) Three 40,000 lb. per hour Water Tube Boilers, with superheaters, mechanical stokers, forced draught fans, etc.
(c) One motor driven pair of 12 kilowatt Boosters.
(d) One 550 ampere-hour Battery of Accumulators, with stands, connections, etc.
(e) One 50-ton Overhead Travelling Electric Crane.

Specifications, Drawings and Forms of Tender may be obtained from Messrs. Preece, Cardew & Rider, 8, Queen Anne's Gate, Westminster, S.W. 1, on payment of a deposit of £5 for each Section, which will be refunded on receipt of a *bona fide* Tender within the prescribed time.

Extra copies of the Specifications may be obtained on payment of Ten Shillings for each copy, which will not be returnable.

Sealed Tenders, endorsed "Thorpe Power Station, Tender for ....," must be delivered to me at my Office not later than ten a.m. on Tuesday, the 11th September, 1923.

The lowest or any Tender will not necessarily be accepted, and the Corporation will not consider any Tender which is incomplete, or which does not include the whole of the work covered by the Specification for any Section.

ARNOLD H. MILLER,
Town Clerk.

Guildhall, Norwich,
August, 1923. B 291

THE SOUTH INDIAN RAILWAY COMPANY, LIMITED,
are prepared to receive

Tenders for the Supply of:—

1. Locks, etc.
2. Acid open Hearth Steel Boiler Plates.
3. Spare parts of Carriages and Wagons.
4. Steel Tyres for Carriages and Wagons.
5. Rolled Steel Disc Wheels and Axles for Carriages and Wagons (Metre Gauge).
6. Helical and Volute Springs.
7. Cylindrical Buffers.
8. Spare parts of Locomotive Engines.
9. Steel Tyres for Locomotive Engines and Tenders.
10. Steel Drawbar Shackles.

Specifications and forms of Tender will be available at the Company's Offices, 91, Petty France, Westminster, S.W. 1.

Tenders addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked:—"Tenders for Locks, etc." (or as the case may be) must be left with the undersigned not later than 12 Noon on Friday the 7th September, 1923.

The Directors do not bind themselves to accept the lowest or any Tender.

A charge, which will not be returned, will be made of 2s. 6d. for each copy of Specifications Nos. 1 and 2 and of 10s. for each copy of Specifications Nos. 3, 4, 5, 6, 7, 8, 9 and 10.

Copies of the Drawings may be obtained at the offices of Messrs. Robert White & Partners, Consulting Engineers to the Company, 3 Victoria Street, Westminster, S.W. 1.

A. MUIRHEAD,
Managing Director.

91, Petty France, S.W. 1. B 299

The Director-General,

INDIA STORE DEPARTMENT, Branch No. 16, Belvedere Road, Lambeth, S.E. 1, requires:—

1. AXLES for railway carriages and wagons.
2. DUPLICATE PARTS of LOCOMOTIVES.
3. SPRINGS, helical and volute.
4. SPRINGS, laminated.
5. BUFFERS, drawbar Cradles and hook ends, &c.

Tenders due on the 4th September, 1923.
Tender Forms obtainable from above. B 295

TO TOWNSHIPS, INDUSTRIAL CONCERNS, &c.

ELECTRICAL PLANT.

Owing to the Dublin Port and Docks Board having decided to obtain their Electric Power in bulk, they are open to consider

Tenders for their Existing

GENERATING PLANT, comprising Four Parsons' Steam Turbines coupled direct to continuous current dynamos, three being 200 Kw. 500 v. and one 75 Kw. 500 v., each unit having its own Surface Condenser and Auxiliaries.

One Highfield Reversible Booster, one Balancer.

Three Babcock and Wilcox Water Tube Boilers working at 200 lbs. pressure with Superheaters, Chain Grates, Feed Pumps and Economizer.

Complete D.C. Switchboard comprising 15 panels.

The plant has been in use since 1907, and can be inspected under working conditions up to early in October, when it will be shut down.

Applications for Inspection to be addressed to the PORT ENGINEER, East Wall, Dublin.

Engineer's Office,
Dublin Port and Docks Board,
30th July, 1923. B 282

SOUTH STAFFORDSHIRE WATERWORKS COMPANY.

SINKING PUMPS.

The Directors of the South Staffordshire Waterworks Company invite

Offers for the Purchase and

Removal from their Cannock Depot of TWO "GRIFF" PATTERN SINKING PUMPS, complete with sling chains, manufactured by Messrs. Joseph Evans & Sons, Wolverhampton.

The Pumps have steam cylinders, 21 in. diameter, and pump barrels, 14 in. diameter by 2 ft. stroke, suitable for 300 ft. head, and each pump will deliver 900,000 gallons in 24 hours.

Applications for permission to view can be obtained on application to the undersigned.

Sealed Offers, addressed to me and marked "Griff Pumps," should be delivered not later than Ten a.m. on Saturday, 25th August.

The Directors do not bind themselves to accept the highest or any offer.

FRED. J. DIXON, M.Inst.C.E.,
Engineer-in-Chief.

Engineer's Office,
26a, Paradise Street,
Birmingham.
8th August, 1923. B 322

NOTTINGHAM CORPORATION.

NORTH WILFORD POWER STATION.

The Nottingham Corporation invite

Tenders for the Manufacture,

DELIVERY and ERECTION of the undermentioned Engineering Works in connection with the above Power Station, viz.:—

Section "I."—STEAM, WATER and other PIPEWORK, VALVES, TANKS, etc., etc.

Specifications and Forms of Tender may be obtained from Messrs. Preece, Cardew & Rider, 8, Queen Anne's Gate, Westminster, S.W. 1, on payment of a deposit of £5 which will be refunded on receipt of a *bona fide* Tender within the prescribed time.

Extra copies of the Specifications may be obtained on payment of Ten Shillings for each copy, which will not be returnable.

Sealed Tenders, endorsed "North Wilford Power Station, Tender for Pipework, etc." must be delivered to me at my Office not later than Ten a.m. on Friday, the 14th September, 1923.

The lowest or any Tender will not necessarily be accepted, and the Corporation will not consider any Tender which is incomplete, or which does not include the whole of the work covered by the Specification.

W. J. BOARD,
Town Clerk.

Guildhall, Nottingham.
10th August, 1923. B 315

THE GREAT INDIAN PENINSULA RAILWAY COMPANY.

The Directors are prepared to receive

Tenders for the Supply of the

following STORES, namely:—

		Fee for Specification.
No. 1.	Helical Springs and Volute Springs	10/-
No. 2.	Steel Fishbolts	10/-
No. 3.	Spare Parts of Carriages and Wagons (W.I. Axleguards, etc.)	10/-
No. 4.	Steel Tyres for Carriages and Wagons...	10/-
No. 5.	Spare Parts of Carriages and Wagons (Buffers, etc. (1)) ...	10/-
No. 6.	Steel Rails and Fishplates ...	£1
No. 7.	Gibs and Cotters	5/-

Specifications and Forms of Tender may be obtained at this Office on payment of the fee for the Specification, which payment will not be returned.

The fee should accompany any application by post. Cheques and Postal Orders should be crossed and made payable to the Great Indian Peninsula Railway Company.

Tenders must be delivered in separate envelopes, sealed and addressed to the undersigned, marked "Tender for Helical Springs and Volute Springs," or, as the case may be, not later than Eleven o'clock a.m., on Tuesday, the 21st August, 1923.

The Directors do not bind themselves to accept the lowest or any Tender.

R. H. WALPOLE,
Secretary.

Company's Offices,
48, Copthall Avenue, E.C. 2.
London, 8th August, 1923. B 319

APPOINTMENTS OPEN.

CROYDON EDUCATION COMMITTEE.

Required for the Central

Polytechnic, a TEACHER of Practical Mathematics and Drawing to apprentice students (Mechanical) for one evening (Tuesday) per week. Fee 18s. per evening of two hours.

Applications with particulars of qualifications to be sent to the PRINCIPAL, Central Polytechnic, Croydon.

J. SMYTH,
Clerk to the Committee. B 294

Wanted for Anthracite

Colliery in Spain, a Colliery MANAGER with experience, who can speak Spanish fluently. An excellent opening with good prospects for a young man with the necessary qualifications.—Address, stating experience, age, qualifications and salary required, B 297, Offices of Engineering.

RESEARCH ASSOCIATION OF BRITISH MOTOR AND ALLIED MANUFACTURERS,
16, Bolton Road, W.4.

Research Engineers Wanted.

Salary £200-£500 according to qualifications. Apply by letter only, to DIRECTOR OF RESEARCH. B 323

Chief Inspector, Electrical

and Mechanical. Must be sound organiser, efficient and capable of controlling staff of inspectors. Must have had experience and held similar position in connection with motor car electrical equipment. Good prospects for right man.—Address, B 326, Offices of Engineering.

Wanted, Engineer for Large

Factory abroad (British Colony), must be good Draughtsman and thoroughly conversant with Linoleum Machinery, and capable of taking full charge of mechanical end.—Address, B 292, Offices of Engineering.

Civil Engineer Wanted,

thoroughly competent, for large Pipe Line Contract. Only thoroughly qualified man, able to control men and costs, need apply. Salary £450 per annum to commence.—BOX O 936, Lee & Nightingale, Advt. Offices, Liverpool. B 262

BOMBAY PORT TRUST.

ENGINEERING ASSISTANT.

The Trustees of the Port of Bombay

Require the Services of an

ENGINEERING ASSISTANT with good experience of Girder, Bridge, and Roof Steel Work Design, Building Construction, and heavy Masonry Work. Should preferably have obtained experience in connection with railway or dock work, and have been some time with a good contractor. Capable of preparing designs and drawings and making calculations under the direct supervision of an Executive Engineer. Salary, Rupees 820 per month, rising annually by Rupees 30 per month to Rupees 940, and if married, with such married officer's house allowance as he may be eligible for under the rules of the service. Three years' agreement. Applications, in writing only, stating age, education, technical qualifications, &c., with copies of testimonials, to the CONSULTING ENGINEERS, Bombay Port Trust, 2, Queen Anne's Gate, Westminster, S.W. 1. B 320

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH.

An Assistant Chief

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THE EVOLUTION OF THE TANGENTIAL IMPULSE TURBINE.

ALTHOUGH the use of a jet of water under pressure to turn a wheel and thus generate power, dates back hundreds and perhaps thousands of years, it was not until about 1850 that the actual development of the tangential impulse turbine as an engineering mechanism commenced.

About this time hydraulic mining for gold was begun in California. In this work the miners were confronted with the problem of handling many large boulders, some of them weighing as much as 10 tons. The distance from manufacturing centres, the high cost of transportation of heavy machinery, and the lack of fuel other than wood, all militated against the use of steam-driven equipment. Some unknown genius conceived the idea of operating a derrick-hoist by means of a water wheel, turned by the same nozzle that was being used to tear down the gold-bearing gravel banks. The first wheels resembled the paddle wheels of a steamer, and were made almost entirely of wood, the only structural material of which there was a plentiful supply. The efficiency was low, but, at that, these so-called 'hurdy-gurdy" wheels furnished by far the cheapest power obtainable, besides being in most cases the only practicable means of developing even the relatively small amounts of power required in that day and in that locality. They soon began to be used, not only by the hydraulic miners, but also by the quartz miners for running stamp-mills, hoists, &c., and in the other small industries of the mining towns as well.

The evolution of the modern tangential impulse wheel from these crude devices has been a slow but steady advance. Among the earliest steps, and probably most important of all, was the invention of the bucket with the central dividing wedge or splitter by Lester A. Pelton about 1880. This type of bucket was considerably more efficient than any that had preceded it.

During the 'eighties, several hundred Pelton wheels were sold, most of them to mining companies in various parts of California, but a considerable number in other parts of the world, not only to miners, but to other power users.

In 1887 the Pelton Water Wheel Company of San Francisco was organised to take over the patents and business controlled by Pelton. At the expiration of the original patents, manufacturers in various countries commenced making wheels with buckets of the Pelton type, and it is noteworthy that practically all the impulse wheels now manufactured, however they may differ in details, make use of a bucket with the central dividing wedge characteristic of the original Pelton patent. In fact, while this usage is not technically accurate, the term "Pelton wheel" is popularly applied to all tangential impulse wheels.

The requirements of the miners and other users of Pelton wheels in the early 'eighties were relatively simple. Since transmission was limited to belts, shafts, gearing, &c., power had to be used close to the point where it was generated. Few wheels had a capacity greater than 100 h.p. Therefore, small quantities of water were needed, usually at relatively low heads, so that pipe-line stresses were low, and a considerable variation in pipe-line pressures might occur without producing a dangerous increase of stress. Load variations were slight and, furthermore, most of the machinery driven was of such a character that a speed variation of several per cent. was not seriously objectionable. Most of such machinery, when running at all, was operated at full, or nearly full, load, so that efficiency at fractional loads was not important. In fact, in many instances, efficiency, whatever the load might be, was a minor consideration, since the water available was in excess of requirements, the principal considerations being the minimum possible first cost, and a negligible cost of operation. Few plants were operated on a 24-hour basis, so that repairs and renewals could usually be made without interrupting service, but even if a shut-down became necessary, the effect was seldom serious.

In contrast to this, impulse wheel design to-day is determined by the requirements of the hydro-electric industry. Long-distance transmission has made it possible for a single plant to furnish energy for thousands of motors and tens of thousands of lamps and appliances scattered over a wide area. Large units, in some cases exceeding 20,000 h.p., are desirable because of the lower costs, both of construction and of maintenance per unit of output. Close speed regulation is essential. Large quantities of water and heavy pressures require that the penstock be safeguarded by pressure regulation. Increased demands for power make it necessary that the maximum possible efficiency, not only at full but also at fractional loads, be obtained, and, in addition, water economy has become an important consideration. Finally, continuous service is demanded, and both the number and the length of shut-down periods must be reduced to a minimum.

The bucket described in the original Pelton patent had nearly square corners and generally straight lines. Buckets of this type are still frequently used for small units where first cost is of primary importance, or where the water available is always in excess of power requirements, but they are not so efficient as the somewhat more expensive ellipsoidal bucket, which, while preserving the central dividing wedge of the Pelton patent, is so shaped that all particles of water travel an equal distance without abrupt changes in direction between the points of entry and discharge from the bucket. The remodelling of old plants by substituting ellipsoidal buckets for those of the older type has been followed by considerable increases of efficiency, in some instances as much as 18 per cent.

Even before Pelton's invention, makers of nozzles had been working on various modifications of the plain nozzle to permit varying the rate of discharge. The simplest method is, of course, to vary the amount of opening of the gate valve in the supply line, but this causes excessive wear when the valve is partly closed, and also lowers the efficiency because of eddy currents. A refinement of this method was a rectangular slot-shaped nozzle with a sliding tongue for closing any part of the slot, but this was subject to the same objections, only in a lesser degree. The provision of several nozzle tips, each bored to discharge a different quantity of water, meets these objections, but it is necessary to shut down the wheel every time tips are changed.

The needle-nozzle, which has become the standard for all but unimportant plants, is open to none of the above objections. The rate of discharge can be varied as rapidly as the safety of the pipe line permits, while the bulb of the needle is so shaped that the nozzle-efficiency is close to unity at all loads. The needle operating mechanism can be arranged for either hand or governor control.

Speed regulation is accomplished by varying the amount of water usefully applied to the wheel. This can be, and sometimes is, done by providing a needle nozzle and adjusting the needle according to the load. Ordinarily, however, this method produces variation in pipe line pressures that is likely to be objectionable, if not dangerous. Speed regulation by deflecting the nozzle so that any desired part of the jet fails to strike the bucket was practiced as early as 1883. As the quantity of water passing through the nozzle is not affected, there is no variation in pipe line pressures.

During the first years of the present century, a number of ingenious devices were developed for use in connection with deflecting nozzles to accomplish better speed regulation or water economy, or both. However, the deflecting type or nozzle was open to serious objections, the most important being the following:—

1. The nozzle body was heavy, and the effort required to move it called for a large and expensive governor. In fact, the inertia of the nozzle body was so great that it was not practicable to design a governor powerful enough to give the quick movements essential to accurate regulation.

2. The trunnions and other mechanism required were expensive.

3. At the ball joint between the fixed and the movable part of the nozzle body, a large cup-leather was required in order to prevent leakage. Wear on this cup-leather under the high pressure involved was rapid, particularly when the water carried grit, and frequent renewals were necessary. On account of the complicated mechanism, each renewal meant a shut-down and a loss of power output and revenue.

These reasons have led to the gradual abandonment of deflecting nozzles for new work, jet deflectors or auxiliary relief nozzles being used instead. Many older plants are, however, still equipped with deflecting nozzles.

Jet deflectors whether of the sleeve or the stirrup type, divert any desired part of the jet from striking the wheel, but do not change the direction of the nozzle.

They are open to none of the objections applying to deflecting nozzles, since they are light enough to be operated quickly with relatively small governor effort, they are comparatively inexpensive, and they have no rapid-wearing parts. Where no storage is available or where the flow of the stream is always greater than the capacity of the wheel, a jet deflector operated by a governor is frequently employed in connection with a plain nozzle.

The next refinement is a hand-controlled needle nozzle and a governor-operated jet deflector. The needle is usually set every hour, or even more frequently. The adjustment may be made in accordance with variation in stream-flow, or else the needle may be set to pass enough water to carry the maximum load expected during the interval between adjustments. The jet deflector takes care of the load variations. This arrangement, as well as the one described in the preceding paragraph, gives excellent speed regulation, and since there are no rapid changes in the rate of discharge through the nozzle, pipe line pressures are unaffected and there are no pipe-line surges. It is ordinarily the best possible design where no storage is available or where water right or other requirements prevent interference with normal flow of the stream. Even where storage is possible, a fair degree of water economy is obtainable, provided the needle is set frequently, and, for many relatively small units, the additional cost involved in the provision of an auxiliary relief needle nozzle would not be justified. The larger plant, however, which is so situated that water economy is of primary importance, requires an auxiliary relief needle nozzle. This device consists of four principal elements as follows:—

1. The main or power nozzle, which is equipped with a needle.

2. The auxiliary relief nozzle, also equipped with a needle and which discharges by-passed water into the tail race.

3. A cumulative differential relay cataract, or "relay element" which controls the action of the relief nozzle, imparting a variable speed of travel, corresponding to the rate of rejection of the load.

4. The mechanical connections between the governor and the needle mechanism.

5. The operation of the auxiliary relief nozzle can best be explained by a concrete example:

Assume a 1,000-h.p. unit is operating under any given pressure, and served by a long pipe line. A load rejection of 500 h.p. occurs. Immediately there is a movement by the governor to restore the speed of rotation to normal by reducing the opening of the power nozzle accordingly.

Coincidentally, but inversely, the relief nozzle opens, and for an instant discharges water at a rate corresponding to the load rejection. The relief nozzle then slowly closes automatically. The rate of closing can be adjusted so that the pressure rise in the pipe is held within any desired limit. The mechanism can be adjusted so that the relief nozzle does not open at all when the load variation is too small to cause a detrimental change in pipe-line pressure, so that in such cases there is no loss of water at all. Even where the load variation requires opening of the relief nozzle, the amount of water that must be allowed to escape before it closes again is small, and the total amount thus used in a given period for regulation and limitation of pressure rises within safe limits is virtually negligible.

Vortex Baffle Plate.—Unless the water from the relief nozzle can be discharged in the open, which seldom happens, some provision must be made for "killing the energy" of this water, or damage will be done to whatever part of the structure is exposed to the force of the jet. The best device for accomplishing this end is the Ensign vortex baffle plate, which turns the water through an angle of 270 deg.,

so that it may be said to expend its energy in discharging against itself.

For the ordinary design and a large water quantity, with a relatively low head, the diameter of the wheel required becomes inconveniently great. Not only is this expensive, but the rotational speed may become objectionably slow, particularly in the case of electric generator drive. Early in the development of the tangential wheel, designers sought to overcome this objection by the provision of more than one nozzle to a wheel. For best results these nozzles should be placed 60 deg. apart. Serious mechanical and constructional difficulties develop when more than two nozzles are used with a horizontal shaft wheel, but as many as six nozzles are occasionally used with a vertical shaft wheel.

Probably the first commercial hydro-electric plant in the United States, and in fact, in the world, was constructed at Appleton, Wisconsin, in 1882. This was a reaction-turbine plant. The record for impulse wheel plants appears to belong to the one built by the Aspen Electric Company, in 1885, at Aspen, Colorado. A Pelton wheel operating under a 70-ft. head was belt-connected to a 60-light Brush dynamo.

Perhaps the most remarkable of the earlier hydro-electric plants was built in 1888 on the Comstock lode, near Virginia City, Nevada. Several years earlier, the Sutro tunnel had been driven to drain the mines, reaching a point 1,700 ft. below the ground surface. This gave the resourceful miners an opportunity to construct an unusual type of plant at the bottom of the Chollar shaft. There were six Pelton impulse wheels, each driving a 100-h.p. Brush dynamo.

The head was 1,680 ft., which would be considered high even in these days. It must be remembered, however, that the miners of California and Nevada had had abundant experience in the laying of high-pressure lines. In 1869, an "inverted siphon" comprising 14,000 ft. of 30-in. riveted iron pipe was laid across the Feather River Canyon. The maximum head was 1,000 ft. Three years later, the construction of a water system for Virginia City included the laying of a 12-in. supply line under a maximum head of 1,720 ft.

At the present time, the highest head hydraulic prime movers in the world are four 3,000 horse-power impulse wheels in a plant near Fully, Switzerland, operating under an effective head of 5,320 ft. Opportunities for economic development at such high heads are necessarily few, and there are probably not more than a dozen plants in the world where the head exceeds 2,000 ft.

The first important step in the direction of high-tension transmission was taken in 1892, when the San Antonio Light and Water Company, of Pomona, California, constructed a plant in San Antonio Canyon, and a 10,000-volt transmission line to Pomona, a distance of 15 miles. The generating equipment consisted of two Pelton impulse wheels, each direct-connected to a 120-kw. generator, the generator voltage being 1,000. This appears to have been the first plant where power was transmitted at greater than the generator voltage.

This plant, like its predecessors, was a single-phase plant.

The first commercial three-phase project, either for generation or transmission, was that of the Redlands Electric Light and Power Company, which constructed its Mill Creek No. 1 plant near Redlands, California, in 1893. The equipment consisted of two Pelton impulse wheels, operating under a head of 295 ft., each direct-connected to a 250-kw. generator. The transmission line was 7·5 miles long and the voltage 11,000.

The success of these pioneer plants paved the way for a rapid increase in size of units and in voltage and distance of transmission, which has continued until the present day. In 1901, a 3,000-h.p. Pelton impulse wheel was installed at the Colgate, California, plant of the Pacific Gas and Electric Company. This was followed in 1904 by a 9,000-h.p. Pelton wheel at the De Sabla plant of the same company. In 1913, two 20,000-h.p. Pelton impulse wheels were installed at the Drum plant of the same company. Other large impulse wheels are three 22,500-h.p. units at the Big Creek No. 2 plant of the Southern California Edison Company, and two 30,000-h.p. units at the Caribou, California, plant of the Great Western Power Company. From a crude device used by a few California miners, the tangential impulse or Pelton wheel has developed until to-day millions of horse-power in all parts of the world are generated by Pelton wheels.

SQUIRREL-CAGE INDUCTION MOTORS WITH HIGH STARTING TORQUE AND REDUCED STARTING CURRENT.

By T. F. Wall, D.Sc., D.Eng.

Whilst the normal type of squirrel-cage induction motor has important advantages as regards simplicity of construction, robustness, cheapness and adaptability for working under bad conditions, there are certain serious drawbacks which have greatly restricted its application in medium and large sizes. If a squirrel-cage motor is connected directly on to the supply mains it is, in effect, at the moment of starting, a short-circuited transformer, and the initial rush of current may be so excessive as seriously to disturb the supply system, so much so in fact, that supply authorities will not usually permit even medium-sized squirrel-cage induction motors to be connected directly on to the supply mains when starting, but insist on some means being provided to check the initial rush of current. The disturbing effects of the initial rush of current at starting are further emphasised by the fact that the power factor is very low and consequently may give rise to a large pressure-drop in the supply mains.

When a squirrel-cage induction motor is connected directly to the supply mains the starting torque may be quite good, If, however, resistances, choking coils, or auto-transformers are used to reduce the current at starting, the starting torque may be only a relatively small fraction of the full-load torque, so that the motor will not start under full load.

A great deal of attention has been given to this problem of starting squirrel-cage induction motors, and numerous proposals have been made for removing the handicap under which this type of motor suffers. For example, squirrel-cage motors may be started on a reduced pressure with the load off, and as the speed increases a centrifugal clutch may be used to couple up the motor to the load. Another method which has been proposed is to split the end-rings of the rotor winding at places one pole pitch apart, the openings in one of the end rings being mid-way between the openings in the other end-ring.* In this way the resistance of the rotor winding is made relatively much larger than if the two end-rings were electrically continuous throughout. When the motor has run up to speed, centrifugally-operated contact makers close up the split rings into electrically continuous rings and thus allow the rotor to act as a normal squirrel-cage rotor. All such devices, however, detract from the inherent simplicity, robustness, and cheapness of the plain squirrel-cage motor, and are rather palliatives than solutions of the problem.

Many years ago, Boucherot proposed to construct the rotor so as to comprise two separate squirrel-cage windings as shown in Fig. 1, in which the outer winding K_1 has a relatively high resistance and low reactance, and the inner winding K_2 has a relatively low resistance and high reactance.† At starting, the frequency of the rotor currents is the same as the supply frequency, and the high reactance and low resistance of the inner winding K_2 make it relatively ineffective at starting, whereas the high resistance outer winding K_1 is most effective at starting and thus provides the motor with a high starting torque. When the motor is running in the neighbourhood of synchronism, however, the frequency of the rotor currents becomes very small, and the impedance of the inner winding K_2 of the rotor becomes relatively small, and this inner winding becomes the dominant winding when the motor is running under normal conditions. The action of the motor is therefore entirely automatic and involves no starting devices.

The purpose of the present article is to show how to predetermine the performance of this type of motor when the constants of the windings are known. Further, the following treatment permits the determination of the effect on the characteristics of the motor of altering one or more of the constants of the electric or magnetic circuit.

Although the Boucherot type of motor has been known for many years, and has had a certain measure of success in the simple form shown in Fig. 1, the following investigation shows that it has serious drawbacks. In recent years, however, interest in the Boucherot type of motor has been greatly stimulated and proposals have been made so to modify it that it may be able to satisfactorily meet the practical requirements.*

The following treatment is applicable not only to the original Boucherot type of motor, but also to the various modifications of it. The plain, double squirrel-cage type, as shown in Fig. 1, will therefore be taken as the standard case of the principle. The performance of the motor may be determined from the equivalent circuit as shown in Fig. 2, which represents one phase of the motor.†

In this representation the well-known device is used of reducing the rotor winding to the stator number of turns and then treating the motor as a static transformer. The effective resistance of the rotor winding in this equivalent circuit is the reduced rotor resistance divided by the slip, and the leakage reactance of the rotor winding is the reduced leakage reactance at the full supply frequency, that is, the reduced leakage reactance when the rotor is stationary.

Let :—

r_1 ohms be the resistance per phase of the stator winding.
x_1 ohms be the leakage reactance per phase of the stator winding.
g_m ohms be the conductance per phase of the stator winding.
b_m ohms be the susceptance per phase of the stator winding.
r^1_{r1} ohms be the resistance per phase of the outer rotor winding K_1 when reduced to the stator number of turns.
x^1_{r1} ohms be the leakage reactance per phase of the outer rotor winding K_1 when reduced to the stator number of turns.
r^1_{r2} ohms be the resistance per phase of the inner rotor winding K_2 when reduced to the stator number of turns.
x^1_{r2} ohms be the leakage reactance per phase of the inner rotor winding K_2, when reduced to the stator number of turns.
s be the rotor slip.

Then if,

P_1 volts is the p.d. per phase applied to the stator winding,
E volts is the back e.m.f. per phase induced by the rotating field.

the vector equation for the stator circuit is

$$P_1 = E + I_1 Z_1$$

where $Z_1 = r_1 + j \cdot x_1$, is the vector of stator impedance per phase.

The vector equation for the magnetising current per phase is :

$$I_m = E \cdot Y_m$$

where $Y_m = g_m - j \cdot b_m$, is the vector of the stator admittance per phase.

The vector equation for the current in the outer rotor winding K_1 (when reduced to the stator number of turns per phase) is

$$E = I'_{r1} \cdot Z'_{r1}$$

where

$$Z'_{r1} = \frac{r^1_{r1}}{s} + j \cdot x^1_{r1}$$

is the vector of the impedance per phase of the outer rotor winding K_1, reduced to the stator number of turns, the rotor slip being s.

The vector equation for the current in the inner rotor winding K_2 (reduced to the stator number of turns per phase) is

$$E = I'_{r2} \cdot Z'_{r2},$$

where

$$Z'_{r2} = \frac{r^1_{r2}}{s} + j \cdot x^1_{r2}$$

is the vector of the impedance per phase of the inner

* See "Electrotechnische Zeitschrift," May 25, 1922, page 723.
† See Boucherot, "Bulletin de la Soc.Int. des El.," 1898.

* See, for example, *The Electrical World*, March 10, 1923, page 567.
† See E. Arnold, "Die Wechselstromtechnik," vol. v, Part I, page 250.

rotor winding K_2 (reduced to the stator number of turns per phase), the rotor slip being s.

The vector equation for the stator current is therefore,

$$I_1 = I_m + I'_{r1} + I'_{r2}$$

that is,

$$I_1 = E\left[Y_m + \frac{1}{Z'_{r1}} + \frac{1}{Z'_{r2}}\right] \quad . \quad . \quad (I)$$

and the vector equation for the applied stator p.d. per phase is

$$P_1 = E + I_1 . Z_1 = E\left[1 + Y_m . Z_1 + \frac{Z_1}{Z'_{r1}} + \frac{Z_1}{Z'_{r2}}\right] \quad (II)$$

These two vector equations for I_1 and P_1, respectively, enable the current and power factor of the motor to be determined for any condition of running.

The torque may be determined as follows: The torque due to the outer rotor winding K_1 is given by

$$T_1 = \frac{m_1 E^2 \left(\frac{r^1_{r1}}{s}\right)}{\left[\left(\frac{r^1_{r1}}{s}\right)^2 + (x^1_{r1})^2\right]}$$

in synchronous watts.

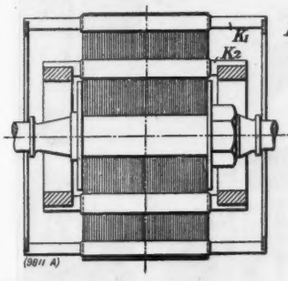


Fig. 1.

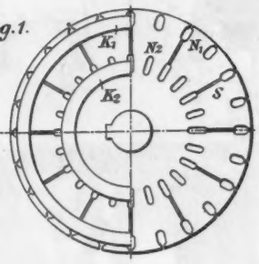
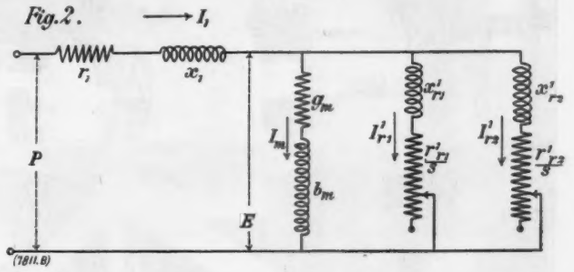
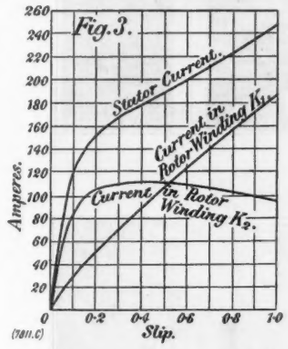
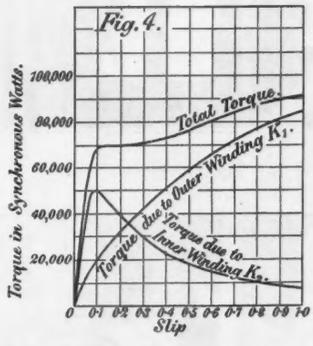
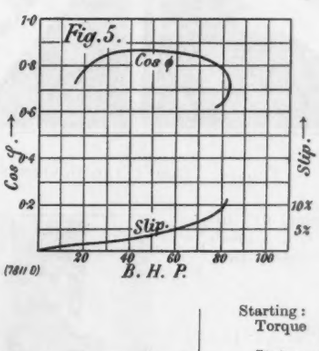


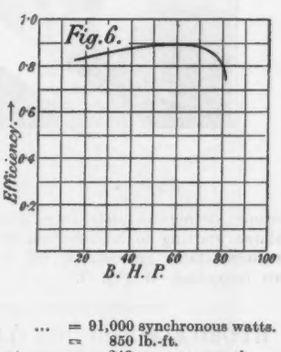
Fig. 2.











The torque due to the inner rotor winding K_2 is

$$T_2 = \frac{m_1 E^2 \left(\frac{r^1_{r2}}{s}\right)}{\left[\left(\frac{r^1_{r2}}{s}\right)^2 + (x^1_{r2})^2\right]}$$

in synchronous watts, where m_1 is the number of phases in the stator winding.

The total torque developed therefore is

$$T = T_1 + T_2$$

in synchronous watts.

The term "torque in synchronous watts" is a very convenient one in connection with induction motor problems, and is defined as follows:—

The total power given to the rotor is the torque in synchronous watts, and is equal to the actual torque on the rotor multiplied by the angular velocity in radians per second, of the rotating field. If it is desired to express the torque in pounds-feet units, then

$$\text{Torque in lbs.-ft.} = \frac{0{\cdot}737}{2\pi n_1} \times \text{(torque in synchronous watts)},$$

where n_1 r.p.s. is the speed of the rotating field.

The mechanical power developed by the motor is therefore

$$\frac{T \times s}{746} \text{ horse power.}$$

As a numerical example of the application of these formulæ, a normal squirrel-cage motor has been chosen which has been designed for 50 b.h.p., eight poles, 750 r.p.m., 289 volts per phase applied p.d.

The constants of the stator winding are as follows: Resistance, $r_1 = 0{\cdot}129$ ohm per phase.

Leakage reactance, $x_1 = 0{\cdot}605$ ohm per phase, that is, the impedance is

$$Z_1 = (0{\cdot}129 + j\,0{\cdot}605) \text{ ohm.}$$

The admittance of the stator winding is

$$Y_m = (0{\cdot}0038 - j\,0{\cdot}0476) \text{ ohms per phase.}$$

In the first place the performance of this motor will be stated when running as a normal squirrel-cage machine and then the performance given when the rotor is provided with a double squirrel-cage winding, as illustrated in Fig. 1.

Case I.—The rotor is wound as a normal squirrel-cage machine. The constants of the rotor winding are:—

Resistance, $r^1_r = 0{\cdot}242$ ohm per phase when reduced to the stator number of turns and phases.
Leakage reactance, $x^1_r = 0{\cdot}230$ ohm per phase when the rotor winding is reduced to the stator number of turns and phases.

Hence the equivalent rotor impedance at any slip s is

$$Z'_r = \frac{r^1_r}{s} + j\,x'_r$$

$$= \frac{0{\cdot}242}{s} + j\,0{\cdot}230 \text{ ohm per phase.}$$

If the performance of this squirrel-cage motor is calculated it is found that the following results are obtained, viz.:—

Starting:		
Torque	=	71,000 synchronous watts.
	=	668 lb.-ft.
Stator current ...	=	314 amperes per phase.
Power factor ...	=	0·40.
At normal full load, 50 b.h.p.:		
Torque	=	40,000 synchronous watts.
	=	375 lb.-ft.
Stator current ...	=	52 amperes per phase.
Power factor ...	=	0·92.
Slip	=	4·6 per cent.
Efficiency ...	=	90 per cent.
Maximum power which the motor can develop	=	128 b.h.p.
Maximum torque which the motor can develop	=	124,000 synchronous watts.
	=	1,160 lb.-ft.

Case II.—Now assume that the rotor is provided with two squirrel-cage windings as shown in Fig. 1 and of which the constants are as follows:—

Outer Winding K_1.

Resistance, $r^1_{r1} = 0{\cdot}85$ ohms per phase when reduced to the stator number of turns and phases.
Leakage reactance, $x^1_{r1} = 0{\cdot}23$ ohm per phase when reduced to the stator number of turns and phases, the frequency being that of the stationary rotor.

The equivalent rotor impedance of this winding for any value of the rotor slip s is therefore,

$$Z'_{r1} = \frac{0{\cdot}85}{s} + j\,0{\cdot}23 \text{ ohms per phase.}$$

Inner Winding K_2.

Resistance, $r^1_{r2} = 0{\cdot}242$ ohm per phase when reduced to the stator number of turns and phases.
Leakage reactance, $x^1_{r2} = 1{\cdot}6$ ohms per phase when reduced to the stator number of turns and phases, the frequency being that of the stationary rotor.

The equivalent rotor impedance of this winding for any value of the rotor slip s is therefore

$$Z^1_{r2} = \frac{0{\cdot}242}{s} + j\,1{\cdot}6 \text{ ohms per phase.}$$

The performance of the motor for these conditions has been calculated by means of the equations given in the earlier part of the paper, and the results are shown in the form of curves in Figs. 3, 4, 5 and 6, respectively.

In order to compare the performance with that of the normal squirrel-cage motor treated in Case I, the following table is useful:—

Starting:		
Torque	=	91,000 synchronous watts.
	=	850 lb.-ft.
Stator current ...	=	248 amperes per phase.
Power factor ...	=	0·53.
For normal full load, 50 b.h.p.		
Torque	=	39,500 synchronous watts.
	=	373 ft.-lb.
Stator current ...	=	54 amperes.
Power factor ...	=	0·87.
Slip	=	3·6 per cent.
Efficiency ...	=	88·8 per cent.
Maximum Power which the Motor can develop	=	83 b.h.p.
Maximum Torque which the Motor can develop	=	91,000 synchronous watts.
	=	850 lb.-ft.

It is clear, therefore, that although the device of using two squirrel-cage windings does provide a large starting torque and requires a reduced stator current at starting, both the power factor and the efficiency at the normal full-load are appreciably diminished as compared with the normal squirrel-cage type of motor. Further, the overload capacity of the motor with the double rotor winding is very much lower than for the normal squirrel-cage rotor. The plain Boucherot type of squirrel-cage rotor has, therefore, serious practical limitations which are mainly responsible for the fact that this type of motor has only found a relatively small application.

The effect of altering the magnitude of the resistance or leakage reactance of either of the rotor windings K_1 or K_2, Fig. 1, is easily ascertained by inserting the appropriate values for the constants in the equations for Z^1r_1 and Z^1r_2.

In the modified type of rotor referred to in *The Electrical World*, March 10, 1923, page 567, the rotor winding K_2 is a progressively wound one,

HYDRO-ELECTRIC DEVELOPMENT IN MEXICO.

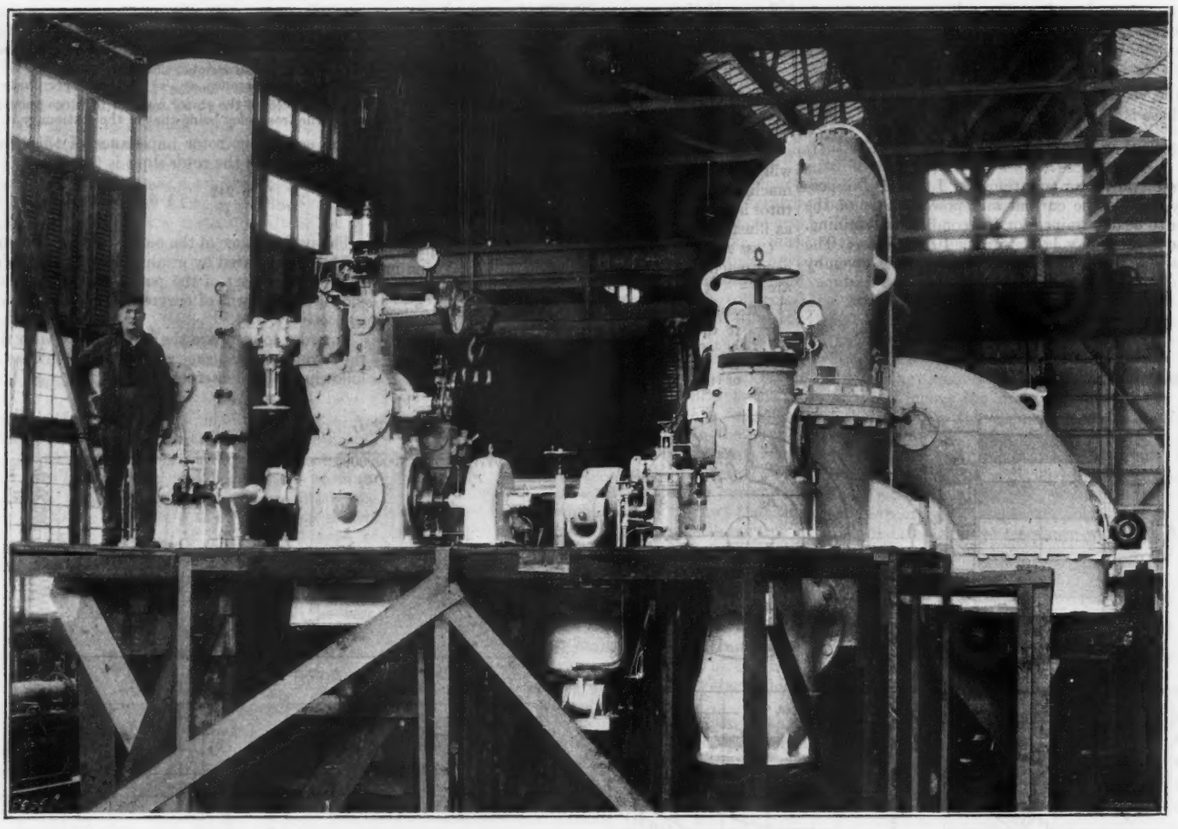


Fig. 1. Turbine and Governor for the Tepexic Power Station.

is open during the initial stage of starting, and this allows starting to be accomplished with a much reduced stator current, as will be evident from an inspection of Fig. 3.

HYDRO-ELECTRIC DEVELOPMENT IN MEXICO.

The Mexican Power and Light Company has been supplying electric energy to the City of Mexico, the mines at El Oro and the various other communities in the vicinity for the past twenty years, the principal source of energy being the water of the Nexaca river and its adjacent streams situated some 125 miles distant from the city, where an auxiliary steam station is maintained. The original programme which, as stated, was inaugurated twenty years ago, called for extension over a long period according to the development of business, and the first step thereof was taken in 1907 involving the construction of various storage works, the principal of which is the Nexaca dam (one of the highest earth dams in the world) and the power house adjacent thereto. The first machines installed here were vertical impulse wheels with two nozzles, a type now regarded as out of date, both these wheels being of European manufacture operating under a head of 1,250 ft. The additional equipment at the same site bringing the total horse-power up to 50,000 kw., installed later, calls for no comment, and this part of the development is now worked up to its full capacity. In spite of the generally disturbed condition of the country and the revolution of 1911, the service has been maintained more or less continuously, and the subsequent conditions having become more stable an increased demand for electrical energy led to the construction of the present works. This is known as the Tepexic power house, and is located on the Nexaca river, but some three miles lower downstream than the original plant, the topography of the country permitting of a working head of 680 ft. with pipe lines only 2,000 ft. long. Immediately below the tail race of the Nexaca plant the water is diverted and carried in a concrete-lined tunnel 2½ miles long to a sand trap and surge tank directly above the Tepexic site.

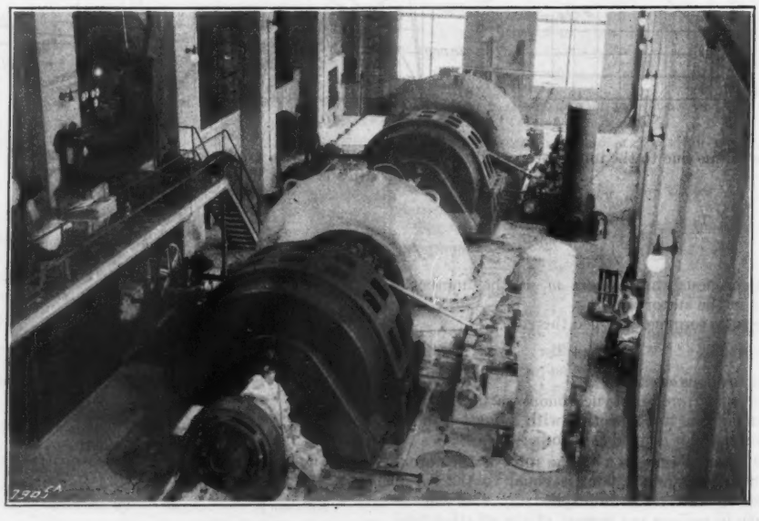


Fig. 2. General View in Tepexic Power Station.

Headworks.—The penstocks are under the control of two gate valves. These are electrically operated and have both direct control and remote control from the power house, and have in addition facilities for hand operation. Between the surge tanks and the gate valves are two 72-in. Venturi meters, this being the inside diameter of the upper 1,410 ft. of the penstocks. This portion is laid at a relatively gentle slope but the remaining distance is at approximately 45 deg. and at the power house is tapered to 63 in.

Between the lower end of each penstock and the butterfly valve controlling the flow to each turbine,

HYDRO-ELECTRIC DEVELOPMENT IN MEXICO.

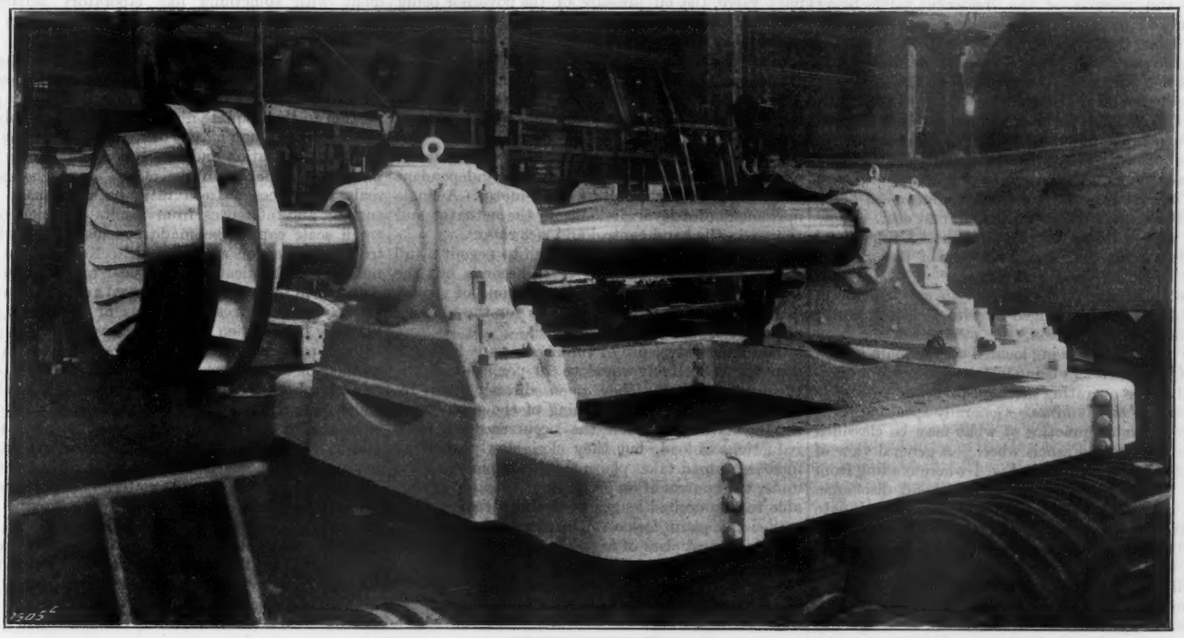


Fig. 3. Turbine Runner and Generator Shaft, Tepexic Power Station.

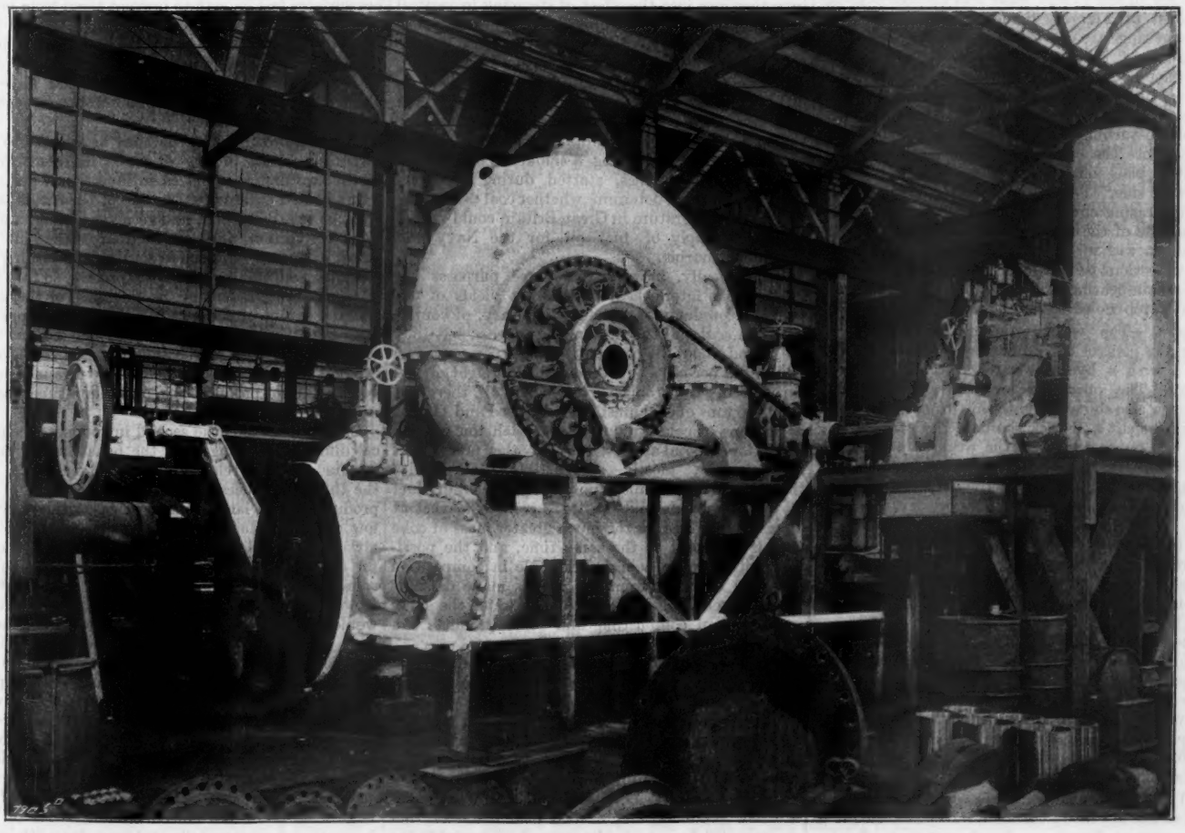


Fig. 4. Regulator Side of Turbine, Tepexic Power Station.

adjustable erection joints are placed, these being of the expansion type so constructed as to permit the two sections telescoping into each other several inches, an arrangement which facilitates erection work and permits of the butterfly valve being dismantled without any other part of the equipment being disturbed.

The Generating Units.—There are two main generating units each comprising a G.E.C. 13,500-kw. 50-cycle generator driven by a single-runner overhung type Francis turbine. These turbines develop a normal horse-power of 17,500 under an effective head of 620 ft. They are both of the same type and are each under the control of a butterfly valve, a type in favour with American engineers as being effective in operation and cheap in first cost. These units were built by The Pelton Wheel Company of San Francisco, and a general view of the plant is given in Fig. 2, page 166.

The butterfly valves referred to are 66½ in. in diameter and are arranged for either electric motor or emergency operation, the mechanism for both types of operation being located on the main switch board, limit switches being installed to prevent overtravel of the operating mechanism.

Details of the Turbines.—Generally speaking these follow orthodox practice of what may be classified as the high head Francis wheel. A general view of one of the units is seen in Fig. 1 where reading from right to left there is the quarter bend discharge, main casing with relief valve in front thereof, gate operating mechanism and rock shaft, a little impulse wheel for operating the oil pressure pumps connected with the governor, the governor itself and finally the oil pressure tank on the extreme left.

The runner is of bronze cast in one piece. It is hydraulically balanced at all loads, a Kingsbury bearing being provided on the outboard end of the main shaft as an extra precaution. This is rigidly attached to the outboard bearing pedestal, and is capable of adjustment in all three dimensions, a feature permitting of accurate centring of the runner during erection.

A view of the runner shaft and its two bearings is shown in Fig. 3. Removable and renewable clearance rings are provided for both the runner and casing covers. The overhung construction, has the advantage of facilitating the replacement of either of these rings or the runner, since the quarter turn discharge may be removed and the turbine entered without disturbing the generator, shaft or bearings. Furthermore the entire regulating mechanism can be left in place since it is outside the casing on the generator side. The latter feature also permits of the ring casing cover being removed from the discharge side of the turbine and all the wicket gates taken out without disturbing the shifting ring or the connections to the governor rock shaft.

The main bearings shown in Fig. 3 are of the ring oiling water-cooled type and are self aligning.

Control.—The water entering the turbine is under the control of the butterfly valve shown in Fig. 4 with a bye-pass valve placed on the top thereof. The operating lever is shown behind. This view also shows the gate-shifting ring, governor, governor shaft and rock shafts. The gate-shifting links are purposely made the weakest part of the connection between governor and guide vanes, this arrangement ensuring that in the case of obstruction to the latter a shifting link would break rather than some other more important part. The gates are also balanced in such a way that in the case of failure of the governor or operating mechanism they will slowly drift to nearly the closed position but remain sufficiently open to avoid shock in the pipe line.

The governor itself is of orthodox design and calls for no special comment.

Special Protective Devices.—In connection with large turbines working under high heads protective devices form a most important part of the equipment and the problems connected therewith call for the highest skill of the designer.

The units are provided with :—

(*a*) An automatic runaway device which will shut down the entire turbine in case of accident to the governor flyballs or breakage of the driving belt.

(*b*) An adjustable load-limiting device which may be set so as to limit automatically the load carried by either turbine to any desired amount.

(*c*) An emergency shutdown device which enables the plant to be shut down by hand by means of the pilot valve, the oil pressure of the governor being used without disconnecting the actuator or affecting its previous adjustment.

(*d*) A device for controlling the actuator from the switchboard consisting of a direct current motor mounted on a bracket attached to the governor and connected by gearing with the speed control mechanism.

(*e*) An auxiliary hand-controlled mechanism using oil pressure but at the same time independent of the main governor and its servo-motor. A single movement of a lever disconnects the actuator and throws in the hand control and *vice versa*.

The servo-motor is large enough to permit a full stroke of the governor in three seconds but the actuator may provide for a longer time of stroke, if desired, or for different periods for the opening and the closing stroke.

The relief valves are of the needle type having a capacity collectively equal to 70 per cent. of the turbine capacity. They open directly and instantaneously with the opening of the guide vanes as the latter close on the occurrence of large reductions of load, but they close slowly when an increase of load takes place, the rate of closure being under the control of an oil dashpot which is adjustable to any desired length of closing stroke. Altogether the plant forms an interesting example of the very latest class of high head hydraulic turbine work and has been built to a guaranteed efficiency of 89 per cent. The work is of a high standard of excellence and reflects every credit on the builders.

THE FUEL RESEARCH BOARD.

III.—Low-Temperature Carbonisation.

Scope of the Investigations.

The Purposes in View.—The main purposes of the investigations into the effect of steaming in vertical retorts described in the previous article (see pages 734, 761 and 811, vol. cxv) was to ascertain the economical effect of the process when used primarily for gas-making. In low-temperature carbonisation, on the other hand, gas is a by-product, and the products principally in view have been either coke or fuel oil. The earlier attempts at using the process aimed chiefly at producing a smokeless coke, while the Board's researches, started during the war, sought likewise to determine whether coal carbonised at a low temperature in Great Britain could yield a sufficient supply of fuel oil for the Navy and mercantile marine.

Economically, however, all three purposes are inextricably interlocked. The exact yields of the principal products of carbonisation vary, of course, with the coal and the carbonising process, but they are round about 70 per cent. coke, 6 per cent. fuel oils, and 9 per cent. gas, taken on the weight of coal carbonised. To produce a ton of fuel oil, therefore, about 16 tons of coal must be carbonised and 11 tons or 12 tons of coke produced, and each ton of coke leaves for disposal about 8½ cwt. of other products of carbonisation, mostly combustible. Obviously, therefore, the economical possibility of making fuel oil in this way depends on there being a market at a reasonable price for the much greater mass of coke that is produced at the same time, and the possibility of the coke being marketable in competition with the raw coal from which it is made depends among other things on the extent to which the large proportion of combustible and other products can be turned to economical account.

The Lines of Inquiry.—Of the three products in question the coke is economically the most important, and the Fuel Research Board's experiments have been directed mainly to throwing light on the circumstances of its production. The scheme of investigation has had to be more complex than was necessary for the inquiry into the effect of steaming in vertical retorts, because low-temperature cokes are new products, and a good deal had—for that matter, still has—to be determined in regard to the conditions of their formation and their structure and properties when formed. The heaviest part of the work lay in providing, as for the steaming investigation, a setting with which processes could be carried out on a works' scale, and the conditions and results recorded by means of the station equipment with something like laboratory accuracy. This was considered indispensable for bridging the gulf between small-scale and large-scale work. In changes of scale in any mechanism or process variations of linear dimensions affect the mass in proportion to their cube, and the surface in proportion to their square; and in processes involving conduction through masses of coal or coke on the one hand, and radiation and convection from, on to and past their surfaces on the other, every change of scale introduces a fresh ratio between mass and surface, and inferences from results obtained on a small scale cannot be made conclusively to those to be expected on a large scale. Nevertheless the number of chemical and physical questions to be determined for each change of coal and temperature was so large that some means of obtaining preliminary information on a laboratory scale was seen to be a practical necessity. It was supplied in the method of assay worked out by Dr. Thomas Gray and Mr. J. G. King, and the use of this method, which was designed primarily and is also used as a means of identifying the character of a coal, and so of classifying it, furnished a second line of inquiry throughout the investigation. This method was used further to provide material for preliminary observations into the structure of coke and the physical circumstances of its formation; and, as will be seen, important practical results were obtained from this third line of inquiry, which consisted largely of pure microscopic research.

Methods of Carbonisation: The Station Plant.

Classes of Methods.—Economical carbonisation requires the process to be completed as rapidly as possible, so as to obtain the best possible output and make the usually considerable capital charge as low as possible. It also requires the products of distillation to be removed from contact with hot surfaces fast enough to prevent them from being decomposed into less valuable substances. For both these purposes it is necessary that the heat used for carbonisation, especially when it is applied at a relatively low temperature, should have to penetrate no great thickness of a substance, such as coal, of low conductivity.

Speaking broadly, this coal may be exposed to the carbonising heat in one of three different ways. In the two first it is placed in layers in a gastight retort heated externally; in one of them this layer must be relatively thin, and receives heat by radiation, convection and conduction, while in the other, means are provided of stirring and turning the coal over continually during the process, so that it is relatively independent of the thickness of the layer and the extent of conduction. The former process may be preceded by briquetting the coal at any selected pressure. In the third method the heat is brought into the mass of the coal by means of large volumes of hot producer gas, or perhaps superheated steam.

Of these methods the second introduces mechanical difficulties arising from the behaviour of metal working parts at relatively high temperatures, and the third introduces a fresh economical fact in the production of a large volume of gas with relatively low calorific value, for which a market might not always be available. In the production of coke for domestic purposes the second may also require some method of briquetting after carbonisation. It was considered accordingly that the first method would present all the circumstances fundamental to low temperature carbonisation with the least additional problems, and that it was therefore the most suitable for the Board's first large-scale experiments. It had, moreover, the considerable advantage that the conditions of carbonisation were as nearly as possible parallel with those of the laboratory apparatus, and the necessary comparisons between the results of large and small-scale working could be made with more confidence than if the large-scale plant introduced circumstances of carbonisation fundamentally different from those of the small.

The Station Plant.—In view of the tentative

character of the plant first installed at the station for this work its details need not be described fully for the present purpose. It consists essentially of a setting of nine special horizontal steel retorts, each retort being 9 ft. long by 2½ ft. wide, built up of slightly dished ⅜ in. mild steel top and bottom plates riveted on to 5-in. channel sections. Each retort is provided with one or two trays, 3 in. deep, and the full width of the retort; the trays when full each hold about 100 lb. of coal, and are slid in one after the other. By cross-pieces they are divided into cages about 3 in. cube. The retorts are arranged near the bottom of a common arched heating chamber, through the front of which they project, the combustion being completed in the upper part of the chamber and the flue gases exhausted at the floor level into chimneys. The retorts deliver into offtakes leading to a common collecting main, with an equipment of condensers, separators, measuring tanks, exhausters, scrubbers, meter, purifiers, and gas holders similar to those provided for the experiments on steaming with vertical retorts. It was recognised, however, that exact determinations could be made more quickly and with greater confidence on the products of a single retort than on those of the whole setting, and one retort was therefore so fitted that its gas could be led through an independent condensing and measuring system and collected in a small separate gasholder from which the laboratory samples were taken after being thoroughly mixed by a hand booster. Temperatures in the combustion chamber were taken by thermocouples connected to an indicator, and the distribution of temperatures within the retorts was thoroughly explored before the carbonisation experiments were put in hand. The supply of fuel gas and air was as in the experiments on steaming.

The Gray-King laboratory assay apparatus consists essentially of a closed bottom silica tube about 2 cm. diameter by 30 cm. long, taking a rubber plug at the open end and provided with an elbow a short distance away from that end. This tube serves as a horizontal retort, and when charged with 20 grammes of coal in a layer occupying about two-thirds of its diameter and held in position by a loose plug of asbestos wool, is connected up to a suitable purifying, collecting and measuring system. A wheeled tubular nichrome-wound electric furnace is then pushed over it so as completely to surround the charge. In this way the temperature can be accurately controlled, and the products of distillation freely evacuated.

On both scales of working the station was accordingly in a position to provide and maintain a steady temperature up to 600 deg. C., to which coal crushed to varying degrees of fineness could be exposed in layers of any desired thickness; to collect and measure accurately the gases and volatile liquids resulting from carbonisation; and in the large-scale setting to control and account for the fuel gas and air used for heating.

RESULTS OF THE INVESTIGATIONS.

The Formation of Coke.—An essential preliminary of the Board's investigations was an examination into the structure of coke. For the details reference must be made to the Board's Report for 1920–1921, in which some particulars with photographs and micro-photographs are given, showing how microscopical problems of some difficulty were solved by Sir George Beilby in continuation of his earlier work on the micro-structure of solids. Broadly, however, the results may be shortly summarised. Coking coal begins, at or below 400 deg. C., to evolve gas, which forms bubbles in the fused or partly-fused mass, just as it does in sugar at a lower temperature. The evolution of the gas from the sugar practically ceases at 400 deg. and the structure, which contains large as well as small bubbles, some burst and some unburst, remains unaltered even when the temperature is raised to 800 deg. or higher. With coke, however, the evolution of gas continues as the temperature rises, even up to 1,000 deg. or 1,200 deg. This gas comes from the walls of the bubbles generated at lower temperatures, thus forming more and more minute bubbles within the bubbles originally blown, and generating a structure with increasingly smaller pores and thinner walls. The formation of this continuous structure is made possible by the fact that at their points of contact adjoining bubbles perforate each other under the pressure of the gas they contain, and the structure ultimately becomes not a collection of discrete cells, but a continuous sponge, through which the gases find their way to the surface and ultimately escape. The minuteness of the pores formed in this way may under suitable conditions far exceed that of charcoal, disclosing films with soap-bubble colours, the thickness of which is of the order of one ten-thousandth of a millimetre. It follows from these results that by the formation of bubbles under appropriate conditions the carbon of the coke is given a form in which an enormous surface is presented for oxidation either by carbonic acid or oxygen, and its practical value for generating heat or entering into reaction is correspondingly enhanced, whether for domestic, metallurgical, or other industrial purposes.

Classifying and Blending Coals.—The examination of coals carbonised in the laboratory assay apparatus disclosed further a practical criterion for selecting coals for coke manufacture, and a means of utilising coals that otherwise would be unsuitable. It has long been known that grave practical difficulties arise through coal swelling while being carbonised, and in the laboratory assay apparatus it was found that coals might be classified for the purpose of carbonisation according as their cokes occupied a larger or a smaller volume than the coal from which they were made. The increase of volume was shown microscopically not to be due to the density of the coke being less than that of the coal from which it is made, the coke being vitreous and structureless carbon, but to gaseous inflation in the manner described; and by choosing from among coals of which the coke occupied a smaller volume than the coal the difficulties arising from swelling could be wholly avoided, and the choice made safely accordingly to the yield of products.

It was found, however, that the same result could be obtained with a much wider choice of coals by fine crushing or grinding fusible coals that by themselves would be quite unsuitable for carbonisation, and mixing them homogeneously in appropriate proportions with infusible or less fusible coals similarly prepared. The proportions in which the selected coals should be mixed were determined quickly by a few trials in the laboratory assay apparatus, and once the proper mixture had been ascertained, little or no foaming occurred during carbonisation, and the resulting coke occupied a less volume than the coal, even though when carbonised alone one highly fusible constituent might have yielded a swollen and weak structure, and the other might have been a non-coking coal, yielding practically an incoherent powder. This method is usually preferable to the use of pulverised coke or breeze as the infusible material, because coke adds nothing to the gas and oil obtained in carbonisation, and the space it occupies and the cost of handling and fuel are therefore dead charges as compared with their application to a coal of low fusibility and high volatile content, which these experiments show can be used equally well for blending with fusible coals.

Briquetting.—In the normal preparation of coke in the station retorts described above the coke forms itself into solid cakes in the process of carbonisation, and coke so made from suitable coal has considerable mechanical strength. Both for mechanical reasons and for increasing the fineness of structure the advantage of briquetting fine coal before carbonisation has been recognised, in particular by Messrs. Sutcliffe and Evans, who have made briquettes without any binder out of ground coal under a pressure of 10 tons per square inch. It was found in the station experience that some coal blends so prepared were lacking in robustness, and that by briquetting at incipient fusion temperature—about 380 deg. C.—under a pressure something less than 2 tons per square inch, a stronger briquette could be made. The subject is understood still to be under investigation.

Time of Carbonisation.—The time required for satisfactory carbonisation was found to depend not only on the temperature but also on the facilities for evacuating the gases and vapours as they are formed. In practice this period was found to be such as would produce about 3,000 cub. ft. of gas per ton of coal carbonised, and leave between 8 per cent. and 12 per cent. of volatile matter in the coke. Some part of the permanent gases was found to arise from the decomposition of the heavy hydrocarbon vapours, which begin to be evolved as soon as the coal begins to be decomposed, and the extent of this decomposition appears to affect not only the value of the products but also the structure of the coke. The time required for completing the decomposition depends, as just mentioned, on the facilities for evacuating the products. Thus while small detached particles of coal, fusible coal, can be carbonised by radiant heat in a few seconds, even a small mass of 20 grammes of fine-ground coal in the assay apparatus requires 20 minutes at 600 deg. C. to complete the carbonisation, and while layers 2 in. thick might be carbonised at about that temperature in about 1½ hours if they were turned over during the process so as constantly to expose fresh surfaces, 3 hours to 4 hours was required for a 3-in. layer in the arrangement described above. Too rapid a carbonisation of a thin layer had a marked effect in weakening the structure of the coke, which might turn out to be of no consequence in manufacturing coke for use as powder or fines, but seemed a serious objection in the production of briquettes.

Effects of Temperature on Plant.—In the arrangement described above the steel retorts showed a remarkable resistance to the conditions in which they were worked. They were used for nearly two years at a working temperature of 600 deg. C., or even higher, without any sign of distorsion or depreciation. Hitherto, however, it has not been found possible to construct gear for charging and discharging continuously and automatically which did not tend to creep and get out of register under the temperature and pressure used.

The Products and Other Industries.—Valuable chemical information has been obtained in regard to the fuel oils resulting from the process, for details of which reference must be made to the Board's report.

The coke itself has proved in domestic hearths to be clean, smokeless and cheerful, lighting easily, and keeping alight perhaps more consistently than most coal. Its low density relatively to coal, and its slightly lower calorific value, mean that a given volume—say, a grate-full—gives out much less heat than the same grate-full of coal; but it appears to give out a larger percentage of its heat—perhaps 25 per cent. more—as radiant heat, and if by increasing the density and perhaps reducing the ash (which with crushed coal should be possible at no great expense) the aggregate heat for a given volume can be made something like that of coal, it should be a most attractive fuel, apart from its inestimable value in avoiding the smoke pollution of the atmosphere.

The probably increase of density and strength, coupled with the extreme fineness of structure and consequent extent of reacting surface, seems likely also to bring it into intimate relation with the metallurgical industries, in which it is likely to show some economy as compared with coke of the ordinary coarse structure.

The gas produced has a calorific value of the order of 1,000 B.Th.U. per cubic foot, and, as suggested by the Board, should have a ready and immediate market for enriching town gas. The declared standard of town gas is usually 450 B.Th.U. to 475 B.Th.U. per cubic foot, or sometimes even rather more, and while as ordinarily made this may be about the thermal value of coal gas, the thermally more economical production with steaming in vertical retorts may yield a gas of somewhat lower thermal value, and the deficiency may turn out to be considerable when the limit of economical steaming has been determined. The present usual means of enriching coal gas consists in adding carburetted water gas, with a calorific value of about 500 B.Th.U., and a large volume of a gas with so relatively low a calorific value is required to produce even a small amount of enrichment. To bring, for example, a 450 B.Th.U. gas up to 475 B.Th.U. would take an equal volume of 500 B.Th.U. enriching gas, while only about 5 per cent. would be required of the 1,000 B.Th.U. gas resulting from low temperature carbonisation, which, moreover, is chemically indisposed to condense and separate out in storage and distribution.

CENTRIFUGAL BLAST-FURNACE BLOWER.

CONSTRUCTED BY THE BRITISH THOMSON-HOUSTON COMPANY, LIMITED, ENGINEERS, RUGBY.

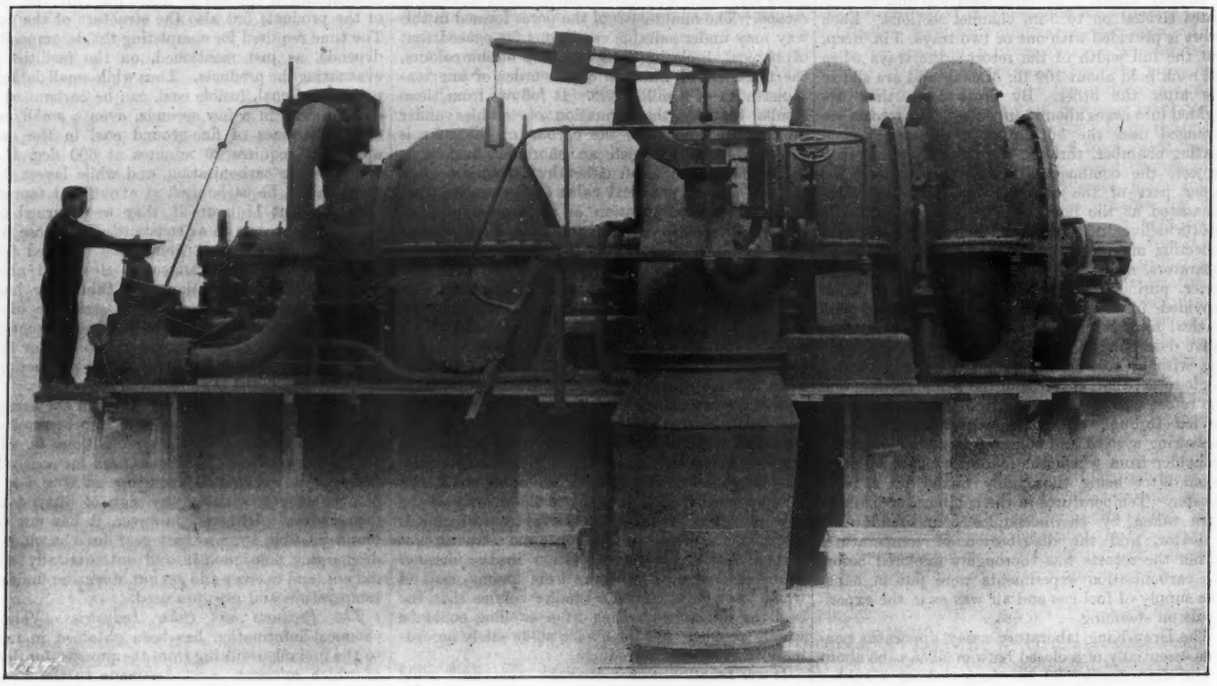


Fig. 1.

Fig. 2.

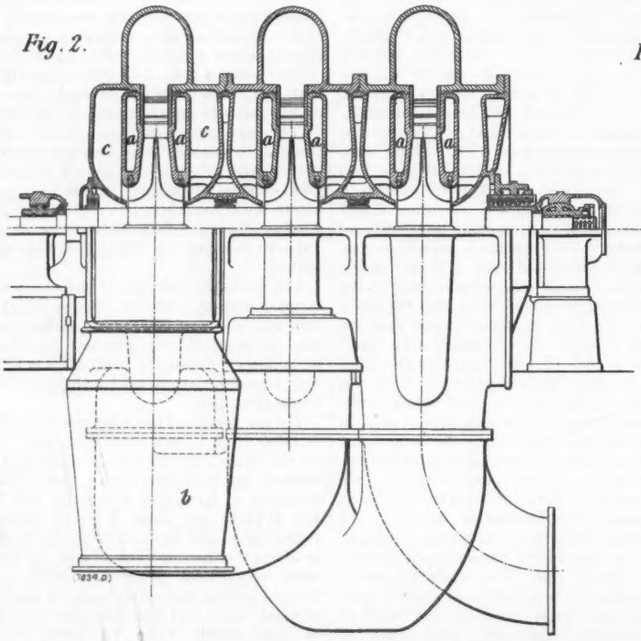
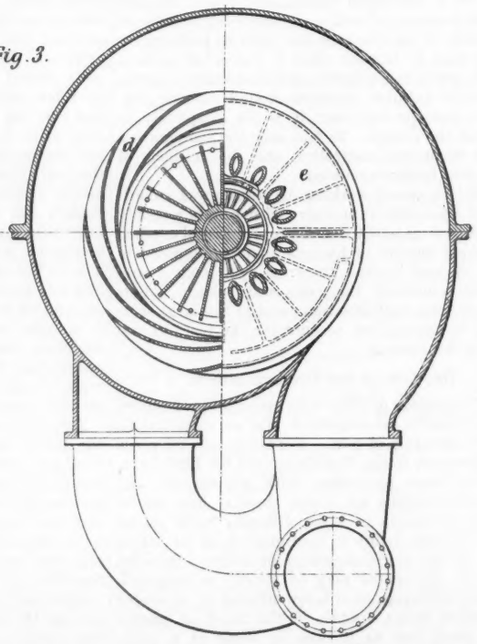


Fig. 3.



We illustrate on this page a blast-furnace blower constructed by the British Thomson-Houston Company, Limited, Rugby, which is capable of compressing 40,000 cub. ft. of free air per minute to 25 lb. or 30 lb. per square inch gauge pressure. The latter figure represents about the limit compatible with the structural strength of a large blast furnace. In normal running a much lower pressure suffices, and the blower is provided with gear which ensures that at all pressures it forces the same volume of free air through the furnace. The resistance offered by the burden to the passage of air through a blast furnace varies very materially from time to time. Sometimes a 10-lb. gauge pressure may give all the air required, but should the material pack, the pressure must be raised. With reciprocating blowing engines this adjustment of pressure is usually effected by speeding up the engines in accordance with instructions received from the furnace; but in the case of the installation represented in Fig. 1 the speed of the blower is automatically adjusted so as to maintain constant the volume delivered.

Longitudinal and transverse sections through the blower are represented in Figs. 2 and 3 respectively. There are, it will be seen, three blowers arranged in series, the walls of each being water-jacketted, as indicated at *a*, Fig. 2. The inlet pipe is shown at *b* and delivers into the chamber *c*, from which it enters the impeller from both sides, so that this impeller is subject to no axial thrust. From the impeller the air is delivered through the diffusers, shown at *d* in Fig. 3, into the U-pipe shown, through which it passes to the next of the blowers in series, which is in all material respects identical with the first. The cooling water to the chambers *a* is passed through the chamber *c* by ports which are shown in section at *e*, Fig. 3. The set of the three impellers mounted on their shaft are represented in Fig. 4, page 171, whilst Fig. 5 shows one of these impellers to a larger scale. The blades, it will be

CENTRIFUGAL BLAST-FURNACE BLOWER.

CONSTRUCTED BY THE BRITISH THOMSON-HOUSTON COMPANY, LIMITED, ENGINEERS, RUGBY.

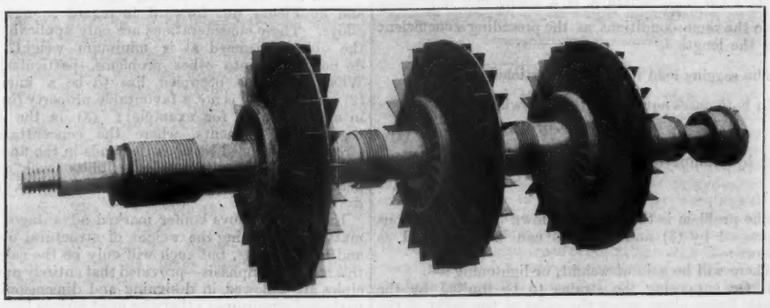


FIG. 4.

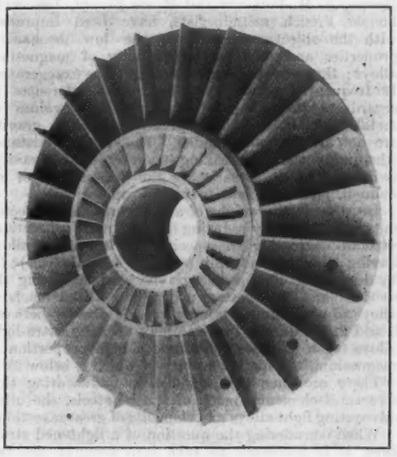
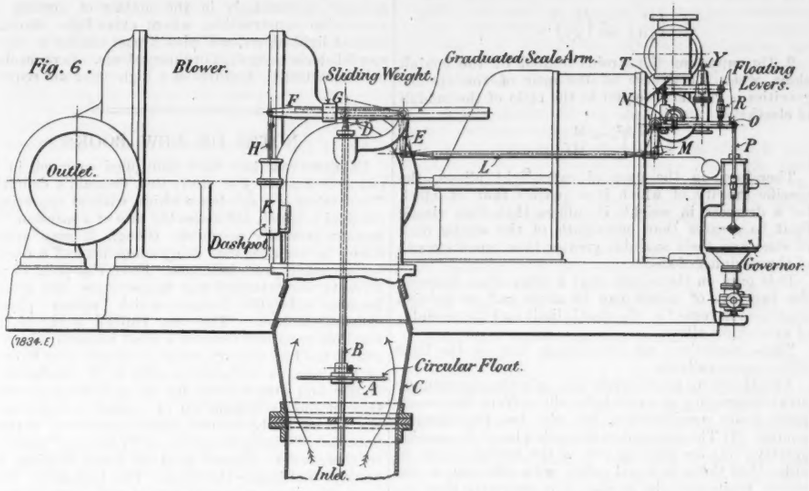


FIG. 5.



seen, are radial and can thus withstand heavy centrifugal stresses.

A section through the automatic governor is shown in Fig. 6. It consists, it will be seen, of a circular float A of sheet iron, which is free to move in a vertical direction in a conical pipe C, which is attached to the blower inlet. The float A is fixed to the rod B by means of which it transmits its motion to a lever D, which swings around a fixed fulcrum. At one end of the shaft to which the lever D is attached will be noted a crank E, and the lever is also fitted with a graduated scale F over which moves a sliding weight G. The scale is graduated in thousands of cubic feet per minute. One end of the lever D is connected through an adjustable rod H to a dashpot K, the function of which is to damp out violent vibrations of the circular float A due to pulsations of the air at the inlet. To the bottom end of the crank E is attached a horizontal adjustable rod L, which is connected to a crank M, mounted on a shaft carried in a bracket affixed to the turbine casing. The other end of this shaft carries a crank N which supports one end of a floating lever O which is coupled by means of the adjustable rod P to the ordinary speed governor. The floating lever O is provided with a connecting link R which couples it to a second floating lever, which operates the pilot valve Y of the relay cylinder controlling the camshaft operating the steam admission valves. The other end of this upper floating lever is connected to the rack T which is meshed with a pinion carried on the end of the camshaft mentioned above.

The action of the governor is as follows: Suppose the blower to be running at a certain fixed volume, which is determined by the position of the sliding weight G on the graduated scale arm F, then so long as the resistance through the furnaces remains constant the volume of air delivered will also remain constant. Suppose now that owing to the hanging of the charge in the furnace, the resistance to the passage of the air is increased, the quantity of air flowing into the inlet of the blower will drop, and hence its velocity past the circular float A will also fall, and the supporting effect due to the velocity of flow past the float A will not be so great as before. The float A will therefore fall, carrying with it the rod B, and by means of the linkwork above described the left-hand end of the floating lever C is raised. This carries up with it the right-hand end of the floating lever operating the pilot valve Y, and thus admits oil to the relay cylinder operating the steam admission valves. The speed of the turbine is consequently increased sufficiently to again cause the same quantity of air to be delivered as before the choking up effect took place, but at a slightly increased pressure, which is sufficient to cause the charge to again descend in the furnace. If, on the other hand, the resistance in the furnace should tend to decrease from any cause, so that the volume of air delivered tends to increase, then the opposite effect to that described above will be produced by the governor.

It will be seen that this device will maintain the volume of air delivered practically constant within any reasonable limits of variation and resistance to the flow of the air through the furnaces, and in those furnaces where this type of governor has been fitted, there has been, the makers state, a considerable increase in the output of the furnaces, whilst a more uniform product was obtained. A centrifugal spring-loaded governor is also fitted and acts as a speed-limiting device, being so arranged that when the turbine reaches a speed corresponding to that at which the compressor would produce the maximum permissible pressure, it moves the governing pilot valve for the servo-motor operating the steam admission valves and prevents more valves being opened. In other words, at this speed it takes the control of the turbine out of the hands of the constant volume governor. The figures tabulated in the statement in the preceding column were observed during the shop trials of one of these blowers.

Steam.	
Average steam pressure in lb. per sq. in. gauge	132·3
Average superheat, deg. F. ...	74·2
Average vacuum corrected to 30-in. barometer	26·61 in.Hg.
Average speed, revolutions per min.	2,450
Steam consumption (uncorrected) in lb. per hour	35,032
Steam consumption corrected to 125 lb. per sq. in. gauge, 100 deg. F. superheat and 28 in. vacuum ...	31,400
Air.	
Barometer	29·68 in. Hg.
Cubic feet of free air per minute, measured at the inlet to the blower	42,150
Cubic feet of free air per minute, measured at the inlet to the blower and corrected to 14·7 lb. per sq. in. absolute and 60 deg. F. inlet temperature	41,500
Inlet air temperature in deg. F. ...	65
Delivery pressure in lb. per sq. in. gauge	14·60
Delivery air temperature in deg. F.	202·60
Cooling Water.	
Total weight of cooling water passing in lb. per min.	3,968
Inlet cooling water temperature in deg. F.	45·6
Total B.Th.U. per minute in cooling water	20,300
Total B.Th.U. in air at delivery ...	104,200
Efficiency (Adiabatic).	
Total a.h.p. less bearing friction ...	2,935
Total adiabatic horse-power ...	2,075
Shaft efficiency (adiabatic)	70·8 per cent.

AMERICAN COAL-MINING HOIST.—The largest coal-mining hoist in the world will be installed at Orient No. 2 mine of the Chicago, Wilmington and Franklin Coal Company, at West Frankfort, Ill. A contract for this hoist has been awarded to the Westinghouse Electric and Manufacturing Company and the Nordberg Manufacturing Company. The Westinghouse Company will furnish the complete electrical equipment for the hoist. The capacity of the hoist motors will be 4,400 h.p., divided in two motors, one mounted at each end of the drum shaft and each having a capacity of 2,200 h.p. at 40 deg. C. rise. Coal will be hoisted in skips, each skip having a normal capacity of 22,000 lb. and a maximum capacity of 26,000 lb. The depth of the shaft is 607 ft. Under normal conditions, the output per hour will be 1,500 tons, and under the maximum conditions this output can be increased to 2,000 tons per hour. The maximum hoisting speed to be obtained will be over 4,000 ft. per minute; the entire operation of a single cycle from the time the skip starts from the bottom until it reaches the dumping position at the top will require only 16 seconds. This high speed of operation involves very heavy peak loads during acceleration and heavy regenerative loads during retardation. The actual load during acceleration is about 8,000 h.p., and the regenerative load during retardation about 4,000 h.p. Power will be supplied to the hoist motors through a flywheel motor generator set, equipped with two 1,800-kw. 600-volt 600-r.p.m. commutating pole, compensated wound direct-current generators driven by a 2,200-h.p. 2,200-volt three-phase 60-cycle 600-r.p.m. wound rotor induction motor. The motor generator set is to be equipped with a built up 90,000-lb. flywheel, 12 ft. in diameter. The control for the hoist will be thoroughly provided with safety devices, and automatic acceleration and retardation are included. In case the operator should be incapacitated at any time, the hoist will automatically slow down and come to rest without causing any damage whatever to the equipment. Although the maximum variation in power during a cycle at the hoist motor is from 8,000 positive to 4,000 negative, the power drawn from the power system by the alternating current induction motor will remain practically constant at about 2,000 h.p. due to the effect of the flywheel, which will give up energy during the retardation period.

LIGHT AND EXTRA-LIGHT ALLOYS.

With reference to the paper by Dr. Leslie Aitchison, on "The Mechanical Properties of Magnesium Alloys," read at the last meeting of the Institute of Metals (see Engineering, vol. cxv, pages 309 and 312), Messrs. A. M. Portevin and R. de Fleury, two well-known French metallurgists, have been impressed with the objections raised to the low mechanical properties and modulus of elasticity of magnesium alloys; these doubts they consider to be exaggerated. It frequently occurs, they add, that inferences in regard to the comparative mechanical values of metals and alloys differing greatly in specific gravity are not always well founded. The specific resistance (the quotient of the breaking strain by specific gravity) is insufficient as a basis for the formulation of an opinion, and may lead to faulty conclusions.

Decrease in the weight of a structure can be effected in two ways: (*a*) By reducing the thicknesses of sections without decreasing the specific gravity, using alloys having a high elastic limit (such as special steels); (*b*) by decreasing the specific gravity and increasing the sections and thicknesses, using light alloys (such as alloys of aluminium having a specific gravity between 3 and 2, duralumin, for example), or using extra-light alloys (such as those containing a high proportion of magnesium, the specific gravity of which is below 2).

There are thus two schools, one advocating thin structural elements, made of special steels, the other advocating light alloys and elements of greater sections.

When considering the question of a lightened structure, it is necessary to take into account the two following fundamental conditions. A structure has to be so designed that it should withstand the stresses due to both the dead loads and the live loads which it is to carry; in the second place it should have sufficient general and local rigidity to resist warping and sagging, both of which are either the indirect resultant of the stresses applied to the structure, or the consequence of external and secondary actions which cannot be prevented. Thus by reducing its thickness to an extreme limit, a thin sheet can withstand tensile stresses, but it saggs under the least compression, and it is deformed and warps under local stresses due to the action of the wind or to local concentrations of stress in the neighbourhood of joints. Rigidity cannot, in short, be neglected, and in order to arrive at a sufficient degree of safety in this connection, thicknesses have to be increased much above the point required to secure safety with reference to the elastic limit considered alone.

The French metallurgists consider the problem from this double standpoint. They state the problem thus: What are the conditions in which there is secured a gain of weight, *i.e.*, a lightening of a structure by substituting for a metal or alloy of specific gravity D, having an elastic limit E and a modulus of elasticity M,* another metal or alloy of specific gravity D^1 having an elastic limit E^1 and a modulus of elasticity M^1 for equal moments of resistance and rigidity?

Taking the simple case of girders of the same length, of similar geometrical section, submitted to a same live load P; the load proper, or weight of the girder being for the present considered as negligible, let

σ be the ratio of linear similitude of the sections,

Ω and Ω^1 the sections of the two girders $\frac{\Omega}{\Omega^1} = \sigma^2$,

I and I^1 the moments of inertia of the sections $\frac{I^1}{I} = \sigma^4$,

and

$$\frac{D}{D^1} = \delta\,;\quad \frac{E}{E^1} = \epsilon\,;\quad \frac{M}{M^1} = \mu.$$

The weight per unit of length of each girder will be ΩD and $\Omega^1 D^1$.

There will be a lightening or a gain in weight if

$$\frac{\Omega D - \Omega^1 D^1}{\Omega D} \geqq 0\,;\text{ or } 1 - \frac{\sigma^2}{\delta} \geqq 0 \quad . \quad . \quad (1)$$

1. The moments of resistance of the sections of the two girders are to the order of

$$a\,\frac{I}{V}\,E \text{ and } a\,\frac{I^1}{V^1}\,E^1$$

V and V^1 being the distances from the neutral fibre to the most stressed fibre $\left(\frac{V^1}{V} = \sigma\right)$, and a a coefficient varying with the method of joining, the nature of the load, the position of the load, the factor of safety, &c.

Equality in the moments of resistance requires

$$\sigma^3 = \epsilon \quad . \quad . \quad . \quad . \quad . \quad (2)$$

and by eliminating σ in (1) and (2) there is found

$$\delta^3 \geqq \epsilon^3 \quad . \quad . \quad . \quad . \quad . \quad (3)$$

* Physicists and all scientists who deal with calculations on the resistance of materials take the letter E for the modulus of elasticity (Young's modulus); Messrs. Portevin and de Fleury have adopted for this the letter M, letter E designating the elastic limit.

2. Warping and sagging are directly proportional to the deformations; equality will therefore be secured by equality in the deflections in the case of bending, or equality in the limit loads according to the Euler formulæ in that of sagging by pure compression.

The value of the deflection is given by an expression of the form $\beta\,\frac{Pl^3}{MI}$ where β is a coefficient depending upon the same conditions as the preceding a coefficient and the length l.

The sagging load limit is proportional to $\frac{MI}{l^2}$.

In both cases equality is reached when:

$$\frac{MI}{\sigma^4} = M^1 I^1, \text{ or } \quad . \quad . \quad . \quad (4)$$

$$\mu = \epsilon$$

and by eliminating σ in (1) and (4) there is found

$$\delta^2 \geqq \mu \quad . \quad . \quad . \quad . \quad . \quad (5)$$

The problem is thus brought down to the conditions expressed by (3) and (5), and can be enunciated as follows:—

There will be gain of weight, or lightening:—

1. On supposing the strains to be limited by the elastic limits alone, when the cube of the ratio of the specific gravities is greater or equal to the square of the ratio of the elastic limits

$$\left(\frac{D}{D^1}\right)^3 \geqq \left(\frac{E}{E^1}\right)^2.$$

2. On supposing the strains limited by the moduli alone, when the square of the ratio of the specific gravities is greater or equal to the ratio of the moduli of elasticity

$$\left(\frac{D}{D^1}\right)^2 \geqq \frac{M}{M^1}.$$

Therefore, in the case of extra-light alloys, the specific gravity of which is a quarter that of steel, for a decrease in weight, it suffices that their elastic limit be greater than one-eighth of the elastic limit of steel and their modulus greater than one-sixteenth of the modulus of steel.

It is only on these lines that a comparison between the two sets of metals can be made and an opinion expressed in regard to the elastic limit and the modulus of extra-light alloys.

These conditions are very amply met by the light alloys now available.

This shows up most clearly not only the exceedingly great superiority of extra-light alloys from the standpoint under consideration, but also two fundamental points: (1) The preponderating role played by specific gravity; (2) the limiting role of the moduli, since, in order that there be equal safety with reference to the elastic limits and the moduli, it is necessary that the cube of the ratio of the moduli be equal to the fourth power of the ratio of the elastic limits.

The intervention of the elastic moduli may be said to have passed practically unnoticed hitherto, and it must not be lost sight of if one does not wish to fall into the general error of looking for very high elastic limits without an increase in the moduli at the same time. The gain would be a most illusory one. Special steels, the modulus of which is limited to about 22,000 kg. per square millimetre, procure no advantage from the point of view of decrease in weight notwithstanding their very high elastic limits.

In the above, the two French metallurgists have only considered the effects of live loads. When the dead loads and the weights of the component parts intervene in local strains, the alloys having a low specific gravity have a further superiority.

These dead loads, or weights of the pieces, must be taken into account not only in the case of static constructions (bridges, and structural work), but especially in that of moving parts, the inertia forces being proportional to the weight of the parts multiplied by the square of the speed.

In having recourse to these alloys, an endeavour is generally made to improve their mechanical properties, and the part played by the specific gravity and the modulus of elasticity is frequently lost sight of. From the foregoing it is possible to deduce the conditions under which the alloying of one metal with another will lead to a gain in weight from the constructive standpoint.

If a quantity x of a metal, such as zinc, be added to a lighter metal, magnesium, for example, there follow variations in the specific gravity D, in the elastic limit E and in the modulus M. Considering the curves showing the variations in these two latter characteristics, elastic limit and modulus, as functions of the specific gravity, there will be a possibility of securing decrease in weight: (1) If the derivative of the elastic limit with reference to the specific gravity is greater than $\frac{1}{2}$ of the quotient of the elastic limit divided by the specific gravity, *i.e.*

$$\frac{dE}{dD} > \frac{1}{2}\,\frac{E}{D}$$

and (2) if the derivative of the modulus with reference to the specific gravity is greater than double the quotient of the modulus divided by the specific gravity,

$$\frac{dM}{dD} > 2\,\frac{M}{D}.$$

Such are the considerations which Messrs. Portevin and de Fleury put forward in regard to extra-light alloys. These considerations are only applicable when the objective aimed at is minimum weight. They do not come into other problems, particularly: (1) When the space occupied has to be a minimum; (2) when rigidity is not a favourable property (in ropes, in a mine cable, for example); (3) in the joining together of elements, where the concentration of stresses on reduced sections demands in the first place great hardness or high elastic limits (such as roller bearings, joints of parts forming a fuselage, pivots, &c.).

Extra-light alloys confer marked advantages in the matter of reducing the weight of structural elements and engine parts, but such will only be the case—and this requires emphasis—provided that entirely new principles are followed in designing and dimensioning the parts and structures; otherwise most serious failures are likely to occur. With care, all the advantages surrounding the use of the new alloys can be turned to account, particularly in the matter of aircraft and submarine construction, where extra-light alloys, as against light alloys, will play a part similar to that of special steels as against ordinary steels, where mechanical characteristic features of a high order are required.

NOTES ON NEW BOOKS.

Catalytic reactions have multiplied so much in the course of a century of study that Ostwald's definition, "a catalyst is a substance which, without appearing in the final product, influences the rate of a reaction," has become generally accepted; though it may amount simply to asserting that every component of a reacting system exerts some influence. From this point of view solvents are catalysts and temperature and pressure become catalytic factors—which means physico-chemical factors. The very fruitful study of these manifold reactions received a great impetus, about the end of the last century, when Professor Paul Sabatier, of Toulouse, in conjunction with J. B. Senderens, A. Mailhe and others, took up the systematic investigation of the hydrogenation of organic compounds by the aid of finely divided nickel and other catalysts Sabatier's "*Catalysis in Organic Chemistry*," translated by Professor E. Emmet Reid, of Johns Hopkins University, Baltimore (London: The University Press; price 25*s.* net), is a very useful and able summary of researches on catalytic isomerisation, substitution, hydrogenation and dehydrogenation, and hydration and dehydration in organic chemistry. The volume of 405 pages, which Professor Emmett has provided with two excellent indices, will be much appreciated by chemists and specialists, though less so, perhaps, by the technical man. It deals with many reactions, but says little on processes and technical apparatus, in the working out of which Sabatier has not had any prominent share. The translation is sometimes rather painfully literal. The volume embodies a section by Professor Wilder D. Bancroft on the Mechanism of Catalysis, in which the theories of contact catalysis are discussed under the three headings: Stoithiometric theory (more generally and better known as theory of unstable intermediate compounds), adsorption theory (the catalyst acts by adsorbing and condensing liquids and gases on its surface and in its pores) and radiation theory (the catalyst emits radiation, which convert the reacting substances into active modifications). Any of these three theories will have to be considered in most cases, and it is rather surprising that the apparent deviations of catalytic reactions from the law of mass action are not especially discussed.

When we noticed the publication of the 24th edition of volume I of the "*Hütte, des Ingenieurs Taschenbuch*," on page 647 of our issue of May 25 last, we mentioned that the volumes of this pocket book are now offered for sale separately. The second volume, since published, is produced by Wilhelm Engelmann and Sohn, Berlin, at the price of 9*s.*, a moderate price for a book of its standard, running into 1,288 pages. The main subjects dealt with in this second volume are methods of measurements, prime movers of various kinds, steam engines and boilers, steam and water turbines, internal combustion engines, machinery for haulage and lifting, blowers and compressors, marine engines and shipbuilding, automobiles, illumination and electrotechnics. Several of these sections have been considerably enlarged and partly re-written; the section on the testing of electric machinery is new. The two volumes do not complete the series; building construction,

hydraulics, ventilation and water supply and railways are left for the third volume.

For one engineer who has to design such a structure as a Forth Bridge there are many thousands who are engaged on the equally useful but more humdrum work of getting out the proportions of ordinary road bridges, and fixing the scantlings of architectural steel work or of reinforced concrete. For this there is little need of a mathematical knowledge extending much beyond simple algebra, but what the draughtsman does want are definite rules and data immediately applicable to his daily work. This need is remarkably well catered for in "*Structural Design in Theory and Practice*," by Henry Adams, M.Inst.C.E., which is a second and enlarged edition of a previous treatise on the "*Theory and Practice of Designing*." The publishers are Messrs. Constable and Co., Limited, and the price of issue 10*s.* 6*d.* net. The text covers the design of wooden structures as well as those of metal and concrete. Numerous illustrations are given of constructional details and there are many examples of fully-worked out calculations.

Clerk Maxwell had the reputation of being constitutionally incapable of thinking wrongly on mechanical matters, and his success in dealing with physical problems lay largely in his determination to form a mental picture of how his concepts worked considered as a piece of mechanism. This method of studying physical questions by means of mechanical models has often been the occasion of animadversions on the part of Continental writers, who have complained that Maxwell's great treatise fails to form a logical and coherent whole. Hertz indeed declared that Maxwell's theory was merely Maxwell's equations. This is probably an under-statement, since a model will generally include more than the differential equations based on it, the derivation of which in fact commonly involves the suppression, either implicit or explicit, of certain relationships, which are sometimes of far from negligible importance. However this may be, it is undoubtedly the case that the style of Maxwell's great treatise is repugnant to many Continental students, and probably, doubly so to the French, whose text books attach prime importance to logic and order. Those who share this feeling will welcome warmly a text-book just published as one of their very valuable "Scientia" series, by Messrs. Gauthier-Villars and Cie., Paris. The book is entitled "*L'Electrodynamique des milieux isotropes en repos d'apres Helmholtz et Duhem*," and its author is M. Louis Roy. The price of issue is 10 francs. In this the author arrives at Maxwell's equations along another and less tortuous route originated by Helmholtz. The preface contains, in a quotation from M. Duhem, an interesting contrast between the methods of Maxwell and those of Gauss. The work of the latter is said to constitute the perfect model of how a research should be presented, but we may add that many mathematicians have complained that though the logic of Gauss is impeccable his work was much less helpful than it might have been, owing to the care which he took to remove all indications as to the line of thought in which his discoveries had really originated.

Writing some 20 years ago the late H. Poincaré referred to the investigations which were then being started with the object of obtaining a glimpse into the internal structure of the atom. The atom, Poincaré said, presented but a very small window through which we might probe its interior. Small as the opening is, however, much has been accomplished, and there has been a marked need for a text book on the subject. This want is capitally met by *The Structure of the Atom* just issued at 16*s.* net by Messrs. G. Bell and Sons, Limited. The author is Professor E. N. da C. Andrade, who, having worked in Rutherford's laboratory, has a first-hand knowledge of these revolutionary researches. In his treatise he explains clearly how experimental facts made it necessary to abandon the almost characterless atom as pictured by Maxwell, and by what slow degrees and by what marvels of insight, intuition and ingenuity we have gradually acquired a considerable amount of information as to the internal constitution of the atoms, of which the dimensions are such that some 300,000,000 of them placed end to end would hardly span an inch. Much, no doubt, has still to be done, and Professor Andrade endeavours to distinguish between conclusions which may be taken as fully demonstrated, and the theories which, whilst unquestionably highly useful, are yet far from completely satisfactory. Indeed in connection with atomic structure matters are at present nearly as bad as they are in optics, where one theory has to be employed to account for the phenomena of interference, and an entirely different one to explain photoelectric effects. The Bohr model of the atom has proved astonishingly apt in the explanation of spectra, but it fits in very badly with chemical phenomena, where a static model of the atom proves much more satisfactory. A word should be said in praise of the excellence of the illustrations which have been selected with great judgment, and the text is both clear and comprehensive. Even those who are no longer in the student stage will find the volume extremely useful as a work of reference, for which its value is enhanced by an ample bibliography.

INDUSTRIAL NOTES.

IT is reported that the Barrow members of the Boilermakers' Society approached Messrs. Vickers, Limited, a few days ago, asking that they be allowed to resume work on the conditions in force prior to the difficulty on the overtime and night-shift question. Messrs. Vickers replied that much as they desired an early termination of the dispute, they were unable to accede to the request, since the constitution of the Shipbuilding Employers' Federation did not permit them to enter into local negotiations on a question in respect to which a national agreement had been arrived at between central organisations acting on behalf of both parties.

The Executive of the Miners' Federation met together last week to prepare their case for submission to the coalowners, following upon the recent miners' conference at Folkestone. At this conference, the executive were instructed to put before the coalowners the following modifications to the national wage agreement:—

1. A modification of the percentages of division of income between wages and profits.

2. An increase in the minimum wage, which is now in most of the districts 20 per cent. above the 1914 standard wage, to a percentage equivalent to the increase in the cost of living above the 1914 figure, say 70 per cent. above the pre-war wage.

3. Fuller detailed particulars of the costs, other than wages, in the monthly ascertainments of income.

A meeting with the coalowners' representatives, presided over by Mr. Evan Williams, chairman of the Mining Association, was held afterwards, when the matter was discussed at length. Mr. Williams pointed out that questions of vital importance were involved in the modification proposals, adding that the Mining Association could not reply until the subject had been considered by the general body of coalowners, and until the opinion of the district associations had been ascertained. When that had been done the Mining Association would again meet the executive of the Miners' Federation. The miners' executive agreed to wait and to take no action in the meantime, until another conference with the owners had been held.

We gave last week a brief abstract of a letter sent by the Industrial Group in the House of Commons to the Prime Minister. The Group has sent a second letter expressing profound disappointment at the statement made last week in Parliament by the Minister of Labour. It states that certain facts quoted by the Minister of Labour are likely to mislead the casual reader. He referred to a steady decline in the number of unemployed. There was such a decline for the first five months of the year, but then the weekly decrease became less and less, and the latest figures available showed that a turning point had been reached, the figures now starting to increase. He had placed the numbers likely to be employed on relief schemes during the winter at 200,000 directly and 100,000 indirectly. If the present rate of unemployment were maintained (and there was nothing in the Minister's speech to encourage the most sanguine to hope that the rate would be checked) this relief would be quite inadequate to prevent larger numbers than last year from becoming workless. The whole question of national vitality was at stake. The Minister acknowledged that the memorandum of the Industrial Group had been examined, but beyond an admission that he was giving "only a first broad outline of our programme," there was little indication of any intention on the part of the Government to adopt the concrete suggestions made by the Group. The problem was urgent and did not admit of a single day's delay. The Industrial Group was not advocating any policy of panic, but a policy which carried the imprimature of the leading industrial, financial and economic brains of the country.

Our Johannesburg contemporary, *The South African Mining and Engineering Journal*, has recently dealt with cotton-growing in the Union. It states in its issue of July 14 that without in any way wishing to detract from the glowing prospects of the cotton industry in South Africa, it should be emphasised that a shortage of native labour to pick the cotton constitutes a real fly in the ointment. In regard to the mining industry, the figures for June showed this industry to be every day feeling the shortage of labour more acutely, and it is known that the report of Colonel S. M. Pritchard, Secretary of Native Labour, and J. A. Asburnham, Chief Magistrate of Johannesburg, will "plump" for increased facilities for supplies from Mozambique. Figures recently published show that there were 49,000 fewer natives employed in mining in South Africa at the end of May, 1923, than in May, 1920. The figures are: 307,731 in May, 1920; 258,707 in May, 1923—thus giving the shortage mentioned.

An important meeting of representatives of the principal producing associations of the British Empire was held on the 2nd inst., at the offices of the British Empire Producers' Organisation, the chairman of the council, Mr. Ben H. Morgan, presiding, for the purpose of considering the representations to be made by them to the forthcoming Empire Economic Conference. It was unanimously agreed that the basic principle of any Imperial economic policy that will provide fuller employment for the people of the Empire and tend to make the separate units more self-supporting is that of a system of inter-Empire preferences, both tariff and otherwise. As the United Kingdom is the only large market open to the Dominions and Colonies for the sale of their food products and raw materials, some substantial system of preferences must be evolved that will provide a first advantage to the home consumer and a second advantage to the overseas Empire producer and thus encourage Empire production and free the British consumer from the present manipulation of foreign trusts resulting in high prices. The meeting affirmed its adherence to the resolutions relating to agricultural preference recently passed by its agricultural section. It unanimously passed a special resolution dealing with preferential import duties. In regard to Government and public body contracts concerning which the organisation recently waited on the President of the Board of Trade by means of a deputation, the following resolution was passed: "Resolved that this organisation ask the conference to recommend to the various Governments represented that all contracts and sub-contracts arising therefrom issued by Government Departments, county councils, municipal and public bodies and bodies enjoying public charters throughout the Empire, should be given to British Empire firms using only British Empire labour and materials and, that whenever it appears in a particular case overwhelmingly advantageous or necessary to employ foreign industry or materials, before awarding the contract the British Empire industry operating on the same lines should be consulted, through its trade association or otherwise, with a view to ascertaining whether the contract cannot be filled without having recourse to foreign industry or materials."

The annual report issued by the Transport and General Workers' Union states that 20 unions have now been welded together into one; on January 1, there was a membership of 300,000. Since then, the Scottish Dockers, the North Wales Quarrymen and the North Wales craftsmen have joined, there being a large increase in the membership. The report states that the carrying through of the amalgamation was a big piece of work. A new machine had to be created, old methods had to be discarded, new procedure formulated, and the membership regrouped. This was done during a period of acute trade depression and unemployment, when employers had been persistently clamouring for reductions in wages and reversion to pre-war conditions. The shaping of the new organisation is therefore a great tribute to the chief officials and executive.

A joint conference between representatives of the National Union of Railwaymen and of the craft unions was held in London, on Wednesday, to consider the question of the railway shopmen employed on the Great Northern Section of the London and North-Eastern Railway. The conference was without any result, and at its close, Mr. J. H. Thomas stated that every effort had been made to effect a settlement because the representatives felt that in a domestic matter it was for the unions themselves to settle their differences. "Unfortunately," added Mr. Thomas, "we failed to agree even to the extent of setting up a committee to investigate the situation." It is announced that a report will be sent to the Minister of Labour, Sir Montague Barlow, who will decide upon the next step to be taken.

A protracted conflict between masters and men in the Swedish iron industry, which has lasted for many months and once threatened to extend greatly, has now ended, an agreement having been effected by the State conciliation commission. As regards the question of hours, the most important point, the views of the employers have on the whole prevailed. Similar conditions were proposed two months ago and were then rejected by the men.

THE PRATT AND WHITNEY SUPER-MICROMETER.

THE illustration annexed shows a machine which is intended to take a place between the ordinary micrometer and the measuring machine of high accuracy. It is manufactured by the Pratt and Whitney Company, of Hartford, Conn., whose agents in this country are Messrs. Buck and Hickman, Limited, 2 to 6, Whitechapel-road, E. 1. This machine was recently exhibited at the Conversazione of the Institution of Civil Engineers when it was manipulated by a number of those attending the function, the results being surprisingly uniform, indicating that its operation necessitates very little practice to secure reliable results.

The machine consists of a heavy cylindrical bed, at one end of which is fixed a headstock carrying an index wheel and measuring spindle, the whole being supported on three points. Towards the other end of the bed is a movable tailstock which can be worked along it by means of a small rack and pinion, the latter being turned by the knurled head shown. The tailstock can be clamped in position by a small handle underneath. The measuring spindle in the headstock moves in a longitudinal direction, but does not revolve with the index wheel; the spindle is screwed for a short length, and the boss of the wheel is screwed internally and forms a nut engaging with the screw on the spindle. The spindle is fitted with a compensating arrangement and springs which maintain a constant pressure on the thrust bearing.

The basis of measurement is the standard inch; eight standard 1-in. blocks are supplied with the machine, which will measure any piece up to 8 in. in length and of a height suitable for the 3¼ in. clear from the anvils to the work-table. A work-table is to be seen in front of the machine in our illustration, and on it are four standard inch blocks, three others being between the anvils. In use the machine is set to the nearest inch by means of inch blocks supported on a slightly channelled bar which is temporarily inserted through a gap in the tailstock, and rests on a pin projecting from the headstock below the measuring spindle. The spindle is marked with a scale ranging from 0 in. to 0·5 in., the graduations being 0·05 in. apart. When setting up, the spindle can be set either at the 0 in. or the 0·5 in. position according to the size of the piece to be checked, the ultimate measurement being obtained by means of a plus or minus reading.

The index wheel has 500 divisions, each graduation representing one ten-thousandth of an inch. The base measurement is obtained by approximately setting the spindle to the blocks, and then obtaining fine contact by means of the index wheel. In connection with the latter a movable zero is arranged on an arm mounted co-axially with the spindle, and this zero is set to correspond with the zero graduation on the wheel and clamped. The spindle can then be run back, the blocks removed and the work inserted and measured.

One of the essential features of the machine consists in the manner in which uniform pressure is secured for the fine contact. The index wheel is provided with a small groove in which is placed a small belt which is crossed over a smaller grooved wheel carried in a swinging arm pivoted in lugs in the front of the machine. This wheel is knurled on two diameters and its weight keeps the belt taut. Any large adjustment of the index wheel can be made by revolving it by means of the small knurled part, the larger part being used when the wheel approaches the final position and fine movement made slowly becomes necessary. The large wheel is revolved until the belt tends to slip, indicating perfect contact with the piece, and thus ensuring as nearly as practicable the same pressure being applied each time to the anvils. Means are provided for taking up wear on the thread of the index wheel, and of correction for small pitch errors of the measuring spindle screw.

30-CWT. TALBOT SUBSIDY MOTOR LORRY.

SOON after the possibilities of motor transport on a large scale were definitely established, the War Office adopted a scheme of subsidising the owners of approved vehicles, in return for which the vehicles were to be at the disposal of the Government in time of national emergency. The lorries subsidised under this scheme were of the 3-ton nominal capacity, but experience gained during the late war showed that there was a large field of usefulness for a vehicle of much lighter build. In order, therefore, to create a reserve of such vehicles in the country, the War Office has decided to encourage their use for commercial purposes by payment of a subsidy of 40*l.* per annum to their owners, the conditions being that the chassis shall be of British manufacture and of approved design, and that the vehicles shall be purchasable by the Government at any time at a pre-arranged price. A specification for lorries with a nominal carrying capacity of 30 cwt. has been issued by the War Office, which is aimed to eliminate every point of weakness which war service had revealed. Lorries constructed to this specification not only earn for their owners the subsidy referred to, but are otherwise popular on account of the very high standard of design and material with which they have to conform.

The vehicle which is illustrated on pages 175 and 178, and on Plate XIII, is a new design of lorry constructed by Messrs. Clement-Talbot, Limited, of Barlby-road, London, W. 10, to meet the requirements of the War Office specification for a 30-cwt. lorry, and to embody every improvement in practice which experience has shown to be desirable. In perfecting the design the company has been guided by the advice of Colonel Hutchinson, D.S.O., whose unrivalled experience of the behaviour of every type of allied or enemy-built vehicle during the war, has been placed unreservedly at the disposal of British manufacturers desirous of building to War Office requirements. There has, moreover, been no question of utilising or modifying existing patterns or details of older types in the new machine. Every part has been re-designed with a view to the most perfect result, so that the vehicle as a whole is exactly as the designer has conceived that it should be. The arrangement of the chassis and equipment are shown in Figs. 1 to 5, on page 178 and Plate XIII, which give elevations and plan. The main frame of pressed steel has three cross-members, the rear member being stiffened by being riveted to a V-shaped bracing, and the centre member taking the form of a cross to prevent the chassis twisting and to maintain its rigidity. The radiator is mounted in the usual position on spherical rubber supports. The axles are connected to the framing only by the springs, the back axle torque tube being attached to the rear of the gear-box by a spherical tube. The engine, clutch and gear-box units are mounted on an elliptical underframe which is supported by a large spherical joint in the front cross-member, and at two-thirds of its length the weight is taken by another cross-member provided with two spherical joints. The construction is light and permits of ready accessibility, while providing absolute rigidity and concentricity of the mechanism. One of the spherical joints is shown in Fig. 12 on page 175.

The engine has four cylinders, each 100 mm. bore by 130 mm. stroke, cast in a block and mounted on an aluminium crank-case. It is shown in Figs. 6 and 7 on Plate XIII. The R.A.C. rating is 24·8 h.p., but the engine actually develops 54 h.p. on the brake. The cylinder head is detachable and each of the four combustion chambers contains two vertical valves, operated by flat tappets, push rods and rockers, all automatically lubricated under pressure. The whole of the valve mechanism is enclosed by an oiltight cover provided with a large spring-hinged oil filler. The inlet manifold is water-heated, and the carburettor is fitted with a variable hot air intake and a partial intake from the crank-case to recover oil vapour which would otherwise escape through the breather. The crankshaft drives the camshaft through a wide helical gear, and the same drive is used for the water pump, magneto and dynamo which are all in line. The pistons are of cast-iron with three pressure rings at the top and three scraper rings at the bottom end. The gudgeon pins are secured in the small ends of the connecting rods and work in the pistons. The oil pump has a vertical shaft driven by skew gear at the middle of the camshaft. Three oil filters are fitted, two on the suction side of the pump and the third on the delivery side. The excess oil delivered by the pump is by-passed back to the inlet before reaching the pressure filter, so that the latter filter works at the lowest velocity practicable, and concentric walls around the suction filters form settling chambers for the oil before the filters are called upon to deal with it. These filters are accessible by removing a cover at the bottom of the crank-case.

The radiator is of the gilled tube type, and the water from the pump is delivered through a sort of injector into the part of the tank communicating with the tubes, another part of the tank acting as a waterseal to the injector. By this means the pressure of the water in the circulating system is maintained somewhat above that of the atmosphere and all troubles from bubbles in the water are eliminated. The radiator is cooled by a four-bladed belt-driven fan, but it is the makers' intention to do away with this fan and utilise the engine flywheel for air circulation. The clutch is of the inverted cone type working inside the flywheel, and as the cone is made of a duraluminum pressing, it has very small inertia and permits of an easy change of gear. The operating mechanism of the clutch is situated within the front part of the gear-box and is therefore fully lubricated. The splines on which the clutch cone slides are also within the gear-box.

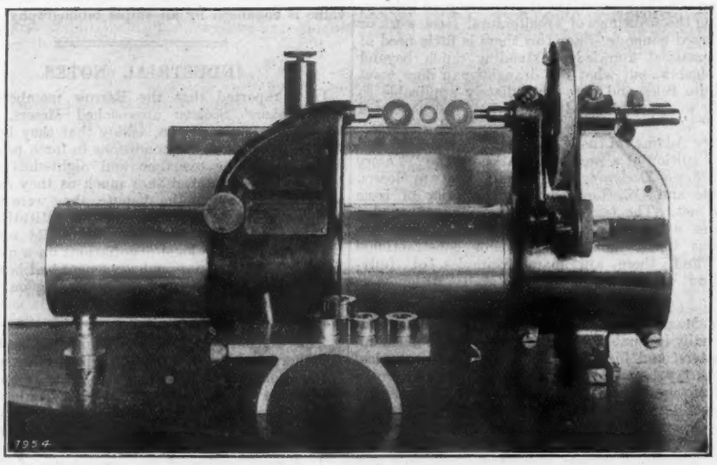
The gear-box, which gives four forward speeds and a reverse, is a separate unit fitted on the rear part of the underframe. The layshaft is immediately beneath the main shaft, and double ball bearings are fitted throughout. The gear-box operating mechanism forms a unit bolted to the top of the casing. It contains two sliding forks, a reverse lever and a positive interlocking device fitted with spring plungers. The change-speed lever is directly above the mechanism and works on a spherical joint. On the cover of the gear-box is bolted a powerful tyre pump of the single cylinder type with easily accessible valves. The air-pump crankshaft carries a sliding gear which can be put into engagement with a constant mesh pinion by a small lever mounted on the gear-box and projecting through the floor board of the lorry. The pump is automatically lubricated by the gear-box. At the back of the gear-box is a spherical joint carrying the end of the torque tube. A rubber sleeve gives additional security against water or dust finding their way into the gear or back axle. The box is shown in Figs. 8 and 9 on Plate XIII.

On the gear-box are fitted the controls, including a foot brake, the accelerator pedal and the hand brake lever. The two rods operating the back axle brakes consist of hollow tubes and are fitted with lubricators which supply oil through the rods for the lubrication of the compensating joints under the back axle, as shown in Fig. 11, page 175.

As the vehicle is fitted with particularly large wheels, the back axle has to be of exceptional strength on account of the increased stress thrown on the teeth of the gears. A considerable speed reduction is also required, and in order to secure the greatest efficiency and resistance to wear, a double reduction gear has been adopted. The back axle proper is formed of two malleable iron castings securing between their joint the torque tube. The torque tube contains the

THE SUPER-MICROMETER.

CONSTRUCTED BY MESSRS. PRATT AND WHITNEY, ENGINEERS, HARTFORD, CONN., U.S.A.



DETAILS OF 30-CWT. TALBOT SUBSIDY MOTOR LORRY.

CONSTRUCTED BY MESSRS. CLEMENT-TALBOT, LIMITED, ENGINEERS, LONDON.

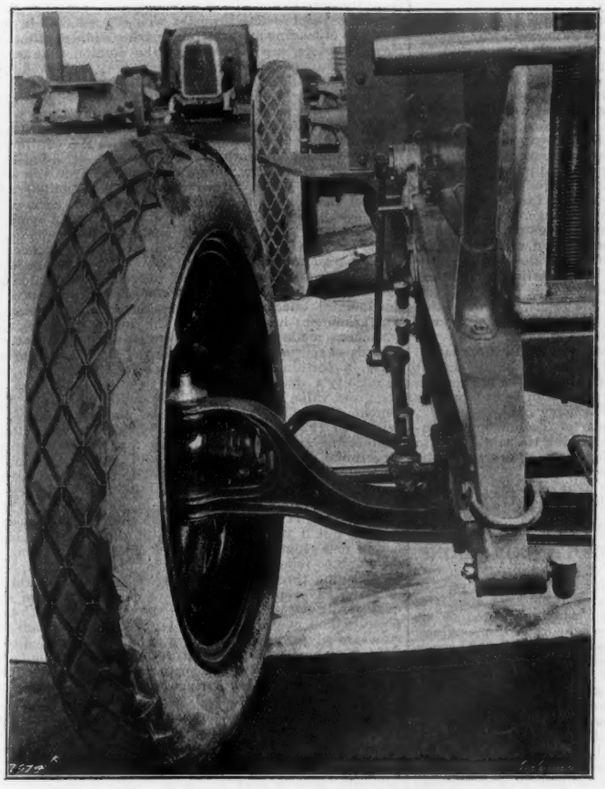


FIG. 10. FRONT AXLE AND STEERING GEAR.

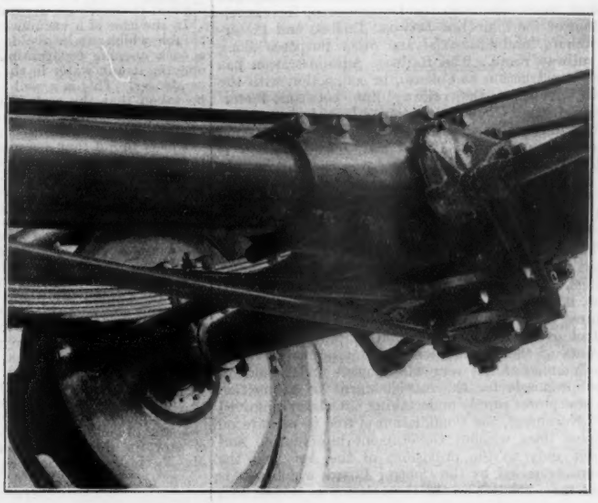


FIG. 11. TORQUE TUBE, DIFFERENTIAL AND BRAKE RODS.

propeller shaft connected to a bevel pinion by splines. The bevel pinion is mounted on three roller bearings, the outer races of which, and of the ball thrust bearings, are fitted in the torque tube. The latter is retained by a screw thread, so that adjustment of the pinion can be effected by rotation of the tube. The crown bevel wheel is carried on an intermediate shaft running on Timken adjustable roller bearings, and on the same shaft is keyed the double helical spur pinion gearing with the large double helical wheel fastened to the differential box.

The back wheels are steel castings made in one piece and running on Timken roller bearings. The wheel drive is external, each axle shaft having a flange bolted directly to the outside of the respective wheel hub. Inside each back wheel is a brake drum, consisting of a steel-ribbed ring. The brake shoes are of die-cast aluminium and are lined with ferodo. They work on oil-less bushes and carry rollers which are operated by the brake cams. Both the hand brake and the foot brake operate on the same drum, each through its own shoe. One of the brake cams is operated by a tube, inside which is the shaft for the operation of the other cam. All the brake gear bearings are automatically lubricated from the axle.

The steering is of the worm and nut type, the casing forming an oil tank inside which the mechanism works. The front axle is a large steel drop forging terminating in forks which are bored for the roller bearings for the swivel pin. The wheels, shown in Fig. 10, are steel castings, and the centres of the swivels are arranged to lie in the plane of the wheels, so that there is the minimum of resistance to the turning of the wheels when steering. The swivel pins are not exactly central, but are set back behind the centres of the wheels to ensure stability of the steering when the vehicle is running. All the steering connections, including those of the coupling bar are fitted with ball joints. These joints are of uniform design and are rendered oil and water tight by spherical felt washers under the balls. These joints are all connected together by tubes which constitute an oil reservoir. Perfection of lubrication is indeed one of the points to which the greatest possible attention has been paid in design. The lubrication of no joint, however humble, has been left to chance or made to depend upon the intermittent care of the driver. The makers have acted on the principle that the maintenance costs of a motor lorry will be extremely low if the mechanism is so mounted that no possible distortion of the vehicle can strain it, and if every moving part is prevented from wearing by a thorough protection, from dust and dirt and there is a thorough system of lubrication. Attention to these three points marks the design throughout, and the vehicle appears in every respect worthy to rank in the forefront of modern practice. With regard to its capacity, we may mention that although nominally rated at 30 cwt. the lorry has shown itself capable, under official test of hauling this load up a gradient of one in five. It was made to stop on the gradient, the brakes were then taken off and the vehicle brought to rest again by either brake after it had run back several yards. Conditions of such severity would, of course, never arise in ordinary commercial work, but the fact that the Talbot lorry will stand such tests is a guarantee to the purchaser of a very large margin over his ordinary requirements.

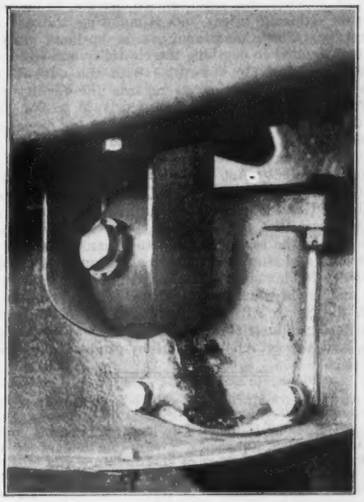


FIG. 12. SPHERICAL JOINT FOR ENGINE UNDER-FRAME.

THE SOUTH AFRICAN ELECTRICITY SUPPLY COMMISSION.

UNDER the Union Electricity Act of 1922 an Electricity Supply Commission has been formed for the Union of South Africa. This Electricity Act is the only co-ordinating legislation that has been passed by the Union Parliament to regulate the supply and control of electricity. For the first time it places electricity supply and control in South Africa on a national basis. Up till 1922 each Province had its own legislation and, except in the Transvaal, that legislation related particularly to the regulation and control of municipal electrical undertakings. The Transvaal Power Act of 1910 provided, *inter alia*, for the regulation and control of all undertakings supplying electricity for sale. Such undertakings had to be licensed and their prices were regulated and controlled.

The Union Electricity Act, 1922, follows the lines of the Transvaal Power Act of 1910 in relation to the control and licensing of private electricity undertakings, for which purpose an Electricity Control Board is constituted under the Act; but, in addition, the Act provides for the establishment of an Electricity Supply Commission whose functions are threefold, *i.e.*, (1) to investigate new or additional facilities for the supply of electricity and for the co-ordination and co-operation of existing undertakings so as to stimulate the provision of a cheap and abundant supply of electricity; (2) to advise Provincial Administrations in regard to electric lighting schemes, &c. promoted by local authorities; and (3) to establish, acquire, and operate power stations of its own for the supply of electricity for state, municipal, industrial, and other purposes.

Before it can establish or acquire a power supply undertaking the Commission must apply to the Control Board for a licence in the same way as a private company. It must also submit its report and proposals to Government for approval, and upon approval of the scheme by Government, the Governor-General authorises the Commission to raise the necessary loan. The Electricity Supply Commission, consisting of one full-time member and two part-time members, was appointed by the Union Government on March 1, 1923. The Chairman and full-time member of the Commission is Dr. H. J. van der Bijl, and the part-time members Messrs. R. Niven and J. R. Fulton, both of Johannesburg.

Several electrical schemes are already engaging the Commission's consideration. An investigation is proceeding in regard to the electrical power requirements and potentialities of the Witbank area. Witbank is the centre of the Transvaal goldfields and an eminently

suitable area for the generation and distribution of electricity on a large scale. A new power station is required at Durban for municipal purposes. The Commission has commenced negotiation with the Durban Municipality, and has offered to build a large station there to provide for municipal and railway and harbour requirements in the Durban area, the electrification of the main line between Durban and Pietermaritzburg, and industrial and other purposes along the railway route. The Railway Administration has under construction at Colenso, in connection with the electrification of the railway line between Pietermaritzburg and Glencoe Junction, a large power station which will contain five turbo-alternator sets each having a normal capacity of 12,000 kw. The intention is that the Commission shall take over the station and the transmission lines in connection therewith, and in the event of the Durban power station being built by the Commission, the stations at Durban and Colenso will be linked up and worked in unison.

The Commission is empowered to raise money by means of loans for the purpose of financing its undertakings, and, in the first four years after its establishment, it may also obtain advances for such sums as it requires from the Union Treasury. It has complete control over all its officers and employees who are servants of the Commission and not public servants. The Commission has very wide powers under the Act. Once proposals for the establishment or acquisition of a new power supply undertaking have been approved by Government, the Commission is free to operate on business lines without Government intervention and subject only to the provisions of the Act and the powers exercised by the Control Board, which stands in the same relation to the Commission as it does to a private power company.

Each station established or acquired by the Commission has to be worked as a separate undertaking, all profits arising therefrom, after meeting operating, interest, renewal, and amortisation charges, to be used towards reducing prices and stimulating the use of electricity. The Commission is a business undertaking intended to combine the elasticity and freedom of action of private enterprise with the advantages of a national institution as regards the facility for raising capital, the elimination of private profits, and the development of the use of electricity for domestic, industrial, and farm purposes. The constitution of the Commission follows no particular precedent. The Union Electricity Act was designed to meet South African conditions. Electricity Commissions have been established and are operating successfully in Ontario, Canada, and Victoria, Australia, but while their main objective is the same, namely, to promote the use of electricity and stimulate a cheap and abundant supply, there are fundamental differences in their constitution and manner in which they operate. Much is expected from the South African Commission in the direction of fostering industrial development, railway electrification, and the establishment of by-product industries.

"Anuario de Mineria."—The complete title of this year-book is "Anuario de Mineria, Metalurgia, Electricidad y demas Industrias de España," and it covers all the Spanish industries, giving particulars of the different firms, the names of the directors and officials, &c. The present volume, for 1923, is No. XXIII, and, like its predecessors, it is issued by the "Revista Minera," Villalar 3, ap. 260, Madrid. Its price is 12 pesetas. The book is an excellent guide for all who have or desire business connections with Spain.

British Chamber of Commerce in Belgium.—The issue, No. 5, for July, of the quarterly journal issued by this Chamber of Commerce, contains, among other articles and notes, one on the Port of Brussels, stating that the port is used by 21 shipping firms, averaging 43 sailings per week for London, Amsterdam, Rotterdam, Antwerp, &c. It is proposed to extend these sailings in the near future to provide regular services between Havre, Dunkirk, Goole, Liverpool, Manchester, Hull and Richborough.

Accelerators in Reinforced Concrete.—According to the *Iron Age*, New York, a number of specimens of 1 : 2 : 4 concrete and 1 : 3 mortar in which steel rods have been embedded were lately broken and an examination of the rods made by the Bureau of Standards, Washington. Calcium chloride solutions had been used in some cases as the gauging liquid. An examination was also made of expanded metal which had been embedded in small slabs prepared from mortar gauged with a proprietary compound of the accelerator type. The specimens were five and six years old and had all been stored out of doors, exposed to the weather. The examination showed that, whilst calcium chloride tends to corrode the reinforcement, the corrosion does not seem serious or of a progressive nature with age, in cases where the reinforcement is completely embedded in the concrete. However, when using accelerators, care should be taken to coat and embed the reinforcement completely and avoid pockets near it. The strength of the specimens which had been exposed to the weather was considerably higher when calcium chloride had been used than when it had not been used.

THE MEASUREMENT OF STEAM PRESSURE.

To the Editor of Engineering.

Sir,—In the accurate measurement of steam pressures there is often trouble with water collecting in the mercury or other gauge used and also in the pipes leading to the gauge. This necessitates a correction which is often difficult to determine accurately.

In the case of a vacuum gauge there is often a similar trouble which can be avoided to a large extent by having a cock opening to atmosphere near the gauge, and by opening it any water in the pipe is blown back into the condenser. This is a well-known device, but care must be taken that the cock is tight and that there are no air leaks between the condenser and the gauge, or a false reading will be obtained.

I have found that a similar device is applicable where pressures above the atmosphere are being measured, by pumping a little air into the pipe leading to the gauge and thus preventing steam condensing in it.

A ¼-in. pipe, 6 ft. long, was connected to a steam pipe, and at the end of it was a mercury gauge, the pipe being purposely sloped down towards the gauge. Normally there was a good deal of condensation and the gauge filled with water, the pipe heating up along the greater part of its length, showing that condensation was occurring. By a small air pump about 1 cub. in. per second of free air was pumped in near the gauge, and when this was done no condensation took place, and the pipe kept cool up to quite close to the steam pipe. When the pump was stopped the pipe heated up and condensation took place. The quantity of air was so small that it did not appreciably affect the reading of the gauge and, in any case, if desired, the air pump can be stopped for a short period while the gauge is being read.

I am indebted to the College of Technology, Manchester, for giving facilities for making the trials, and to Mr. T. H. Jones, M.Sc.Tech., for carrying out the tests.

Yours faithfully,

Gerald Stoney, D.Sc., F.R.S.

College of Technology, Manchester.

RADIATION FROM GASEOUS EXPLOSIONS.

To the Editor of Engineering.

Sir,—I should be much obliged if you would publish the following short calculation of mine regarding heat contained in radiation emitted when mixtures of air and gases are fired as in internal-combustion engines.

From experiments mentioned in Ewing's "Thermodynamics" (page 261) it has been found that when OH_2 is formed by the burning of hydrogen, most of the radiant heat is given off with a wave-length $2{\cdot}8\ \mu$, and some has a longer wave-length. Also that when carbon dioxide is formed, most of the radiant heat is in a band with wave-length $4{\cdot}4\ \mu$, but some in two wave-lengths about $2{\cdot}7\ \mu$ and between $14\ \mu$ and $15\ \mu$.

From Bohr's work we know that certainly atoms and very probably molecules radiate energy through the change in orbits of electrons in quanta ϵ, proportional to the frequency ν of the radiation. As is well known, $\epsilon = h\nu$, where h is Planks' constant. Now if we argue that each molecule of CO_2 or OH_2 emits a quantum measured by the frequency ν, we can calculate for wave-length $2{\cdot}7\ \mu$ and OH_2

$$\epsilon = h\nu = 6{\cdot}5 \times 10^{27} \times \frac{31 \times 10^{12}}{2{\cdot}7} \text{ ergs.}$$

and if 1 litre of air burns with H to a mixture of steam in nitrogen the number of molecules OH_2 formed will be

$$N = \frac{27{\cdot}5 \times 10^{21} \times 2}{5}$$

and there will be radiated

$$6{\cdot}5 \times 10^{27} \times \frac{31 \times 10^{12}}{2{\cdot}7} \times \frac{27{\cdot}5 \times 10^{21} \times 2}{5} \times 10^{-8} \text{ kg.m.}$$

$$= 82 \text{ kg. m.}$$

The total heat liberated by the burning of hydrogen in 1 litre of air would be roughly equivalent to 450 kg.-m. So that, roughly, 18 per cent. of the total heat would be found in radiation. This agrees with experiments mentioned in the same place.

In the same manner, if the wave-lengths observed when CO_2 is formed are used, we again arrive at the result that 18 per cent. of the total heat is found in the radiation. I shall be glad to know if this form of presenting the question has already been published and has been generally accepted.

I am, dear Sir, yours faithfully,

A. Melencovitch.

3, Sophocles-street, Athens, July 30, 1923.

Motor Cars in China.—In 1922, according to the Tientain trade report, 238 motor cars were imported, being 115 from the United States, 63 from Germany, 21 from Italy, 6 from Great Britain, 18 from France, and 15 from various other countries.

Industrial Research in China.—The Peking Technical College has organised an Institute of Industrial Research. The institute's work consists in collecting and classifying products from all over China, both raw and manufactured, and investigating the nature and quality of materials with a view to devising means for improvement or to extending their use. Collecting is being carried out by sending out circulars and publishing advertisements requesting samples and special information. Blank forms are provided containing a list of inquiries concerning name, form, variety, where and how produced or manufactured, trade mark, sellers, market, export, quantity produced, local price, local uses, &c. The institute offers to pay all expenses of forwarding and delivery in connection with materials submitted.

NOTES FROM SOUTH YORKSHIRE.

Sheffield, Wednesday.

Iron and Steel.—Although business has suffered its usual midsummer reaction, and the placing of new contracts to cover expiring commitments is somewhat sluggish, the outlook appears to be clearing. Viewed from the standpoint of the engineering and steel trades, a more hopeful feeling prevails. This is reflected in the speeches of leading manufacturers, who, while cautious in their forecasts, are generally of the opinion that early developments of a favourable nature may be looked for. Mr. William Clark, president of Sheffield Chamber of Commerce, who is intimately in touch with engineering activities on a wide scale, stated on Monday there were indications that trade would soon improve. A feature of satisfaction to the finished sections is the continued fall in official quotations of raw and semi-finished materials. Hematites, forge and foundry iron are still on the down grade. Hard and soft basic billets are cheaper than for some months past, and during the past week acid billets have declined 10*s.* per ton to an average quotation of 12*l.* 10*s.* Offset against these reductions is the increase in the wages of iron workers, which came into operation from Monday last. This increase was based on the high selling values prevailing some months ago, and, so far as bar iron is concerned, must have a detrimental effect in the direction of new business. The armament branches are in the dumps following the statement made on behalf of the Government that no subsidy of special plant may be looked for. On the other hand, a certain measure of hope is drawn from the Admiralty's declared intention to place contracts of the gross value of half a million pounds mainly for the benefit of Sheffield and Barrow to cover requirements arising in 1924 and the following year. On the purely engineering side output of heavy machinery and constructional materials on railway and colliery account is on the increase, while the automobile trades are taking larger tonnages of tools and special fittings. This week's letters have brought several very big inquiries from the Colonies. It is inadvisable at the moment to disclose details, but if the special nature of these requirements can be met economically, the work thus furnished should do much to relieve the still heavy burden of unemployment ruling throughout the district. The new tarnish-resisting silver plate discovery is of interest from the engineering standpoint. One of the tests made with this plate, which contains sufficient pure metal to rank as standard silver, was in the form of fittings attached to a light car which participated in recent hill-climbing trials during stormy weather. Except for a coating of dust, easily removed, these fittings retained their original polish. It is also intended to lay down special plant for the utilisation of this discovery in the manufacture of plated hardware and builders' requirements.

South Yorkshire Coal Trade.—Business this week is at a minimum owing to the holiday stoppage, and prices generally show a weak tendency. This is reflected in a further relapse of 1*s.* per ton in Derbyshire best small nuts. Output of house coal has been restricted, though there is still an excess tonnage at colliery sidings. Best slacks are an active market for inland consumption, while deliveries of steam hards, both on export and home account, are maintained at a fair level, despite the damaging effect of the dockers' dispute. The advent of cheaper coke, which is urgently needed by the steel and allied trades, is hindered by recurrence of buying on Continental account. Quotations:—Best handpicked branch, 32*s.* 6*d*, to 34*s.* 6*d.*; Barnsley best Silkstone, 26*s.* 6*d.* to 28*s.*; Derbyshire best brights, 25*s.* to 27*s.*; Derbyshire best house coal, 22*s.* 6*d.* to 23*s.* 6*d.*; Derbyshire best large nuts, 20*s.* to 21*s.* 6*d.*; Derbyshire best small nuts, 15*s.* to 16*s.*; Yorkshire hards, 21*s.* to 23*s.*; Derbyshire hards, 20*s.* to 22*s.*; rough slacks, 11*s.* 6*d.* to 13*s.* 6*d.*; nutty slacks, 10*s.* to 12*s.*; smalls, 7*s.* to 9*s.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

Middlesbrough, Wednesday.

The Cleveland Iron Trade.—Little new of moment is ascertainable concerning Cleveland pig-iron. A 5*s.* fall in No. 1 quality is of little moment as there is next to none of that grade available for sale, and demand is negligible. No. 3 is down 1*s.* 6*d.* and foundry 4 is also cheaper. Business is still very quiet, but some producers are not without hope of some improvement in demand shortly. Recognised f.o.t. makers' works and f.o.b. Tees market quotations now stand:—No. 1 quality, 110*s.*; No. 3 g.m.b., 102*s.* 6*d.*; and No. 4 foundry and No. 4 forge, each 97*s.* 6*d.*

Hematite.—The blowing out of two or three furnaces may strengthen somewhat the hematite branch which has been exceptionally weak for some time past, but stocks are still fairly heavy. Normanby Iron Company are putting two furnaces out of operation, and other firms are likely to damp down a furnace or two. Slightly better inquiry is reported. Nos. 1, 2 and 3 are obtainable at 99*s.* for home consumption or for shipment abroad, and No. 1 at 100*s.*

Foreign Ore.—Business in imported ore is lifeless. Best rubio remains nominally 23*s.* c.i.f. Tees.

Blast-Furnace Coke.—Durham blast-furnace coke is still scarce, and the general quotation to local consumers is 41*s.* delivered.

Manufactured Iron and Steel.—Producers of some descriptions of finished iron and steel report rather more inquiry from overseas, and Continental competition rather less keen, but with actual sales still maturing slowly. The one outstanding exception is the sheet departments. Manufacturers of sheets are very busy and heavily sold

over the next few months. Among the principal market quotations are:—Common iron bars, 12*l.*; iron rivets, 14*l.*; packing (parallel), 8*l.* 10*s.*; packing (tapered), 11*l.* 10*s.*; steel billets (soft), 8*l.* 10*s.*; steel billets (medium), 10*l.*; steel billets (hard), 10*l.* 5*s.*; steel boiler plates, 14*l.*; steel ship, bridge and tank plates, 10*l.*; steel angles, 9*l.* 10*s.*; heavy steel rails, 10*l.*; fish plates, 14*l.*; black sheets, 13*l.* 15*s.*; and galvanised corrugated sheets (24-in. gauge, in bundles), 19*l.* 5*s.*

Shipments of Iron and Steel.—July shipments of iron and steel from Middlesbrough—including 6,229 tons of pig-iron shipped at Skinningrove—totalled 80,539 tons, composed of 36,370 tons of pig-iron, 493 tons of manufactured iron, and 43,676 tons of steel. Of the 30,141 tons of pig-iron cleared at Middlesbrough the principal recipients were:—Germany, 15,875 tons; Wales, 3,950 tons; United States, 2,200 tons; Scotland, 1,795 tons; Denmark, 1,594 tons; Belgium, 1,412 tons; and Italy, 1,000 tons. Straits Settlements, with an import of 127 tons, were the largest manufactured iron customers. As usual, India was the heaviest buyer of steel, taking 11,369 tons, and other chief importers of steel were:—Egypt, 5,999 tons; Victoria, 3,126 tons; Natal, 2,976 tons; New South Wales, 2,144 tons; South Australia, 1,467 tons; and China, 1,451 tons.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—In the Scottish steel trade the conditions continue to be of a very unsatisfactory character, and there is very little doing at most of the works. Orders on hand for the rolling mills are few in number, but for structural material there exists quite a good demand. The orders already booked amount to a fairly heavy tonnage, and plant is likely to be kept actively employed for many months to come. Inquiries are also very good for future lots. Black sheet makers are not very busy on home orders, but some works have a fair number of orders on hand for thin sheets for export. The general export trade is exceedingly slow, and shows little sign of picking up yet awhile. Current prices, although 5*s.* per ton easier for ship plates and angles, are not to the liking of buyers, who continue to hold back. The quotations to-day are as follow:—Boiler plates, 13*l.* per ton; ship plates, 10*l.* per ton; sections, 9*l.* 15*s.* per ton; and sheets, $\frac{1}{16}$ in. to $\frac{1}{4}$ in., 12*l.* 10*s.* per ton, all delivered Glasgow stations.

Malleable Iron Trade.—No change has taken place in the malleable iron trade of the West of Scotland this week and only a portion of the plant is in operation. The demand of late has been exceedingly poor, and orders are not coming in as freely as might be expected. Business may get better before long, but the waiting process is getting tiresome. The current price of "Crown" bars is 12*l.* per ton, delivered Glasgow stations.

Scottish Pig-Iron Trade.—The demand for Scottish pig-iron continues very slow and consumers are not giving out orders of any consequence. The home trade is requiring very little overall, of course, but there are a few instances where orders might be placed a little more freely. The quietness at the steel works is the cause of the poor demand for hematite iron, but buyers of foundry sorts are acting with much caution. Producers are very anxious for business, and are prepared to shade current prices to secure a few good lines to keep plant moving. To-day's prices may be taken as under:—Hematite, 5*l.* 12*s.* 6*d.* per ton, delivered at the steel works; foundry iron, No. 1, 5*l.* 10*s.* per ton; and No. 3, 5*l.* 5*s.* per ton, both on trucks at makers' yards.

Scottish Pig-Iron Shipments.—The shipments of Scottish pig-iron from Glasgow Harbour for the week ending last Saturday, August 4, amounted to 1,450 tons. Of that total, 1,312 tons went foreign and 138 tons coastwise. For the corresponding week last year the figures were 1,275 tons foreign and 89 tons coastwise, making a total shipment of 1,364 tons.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—Owing to the intervention of the August Bank Holidays, and the suspension of work in the coalfield for three days and at the docks for two days, there was little business transacted on the coal market during the past week, as operators generally had previously covered their holiday requirements. The general tendency of the market, however, continued irregular, notwithstanding that outputs would be considerably reduced over the holidays and that sellers were expecting this to have a steadying influence. News that the Belgians were prohibiting the transport of Belgian coal into France, too, was expected to bring about an improvement in the French demand. Best Admiralty large coals were steady at 30*s.* to 32*s.* 6*d.*, with seconds round 29*s.*, and the leading Monmouthshires from 27*s.* to 29*s.* 6*d.* Other grades, however, were freely offered and prices were irregular and dependent on individual circumstances. Best steam smalls realised no more than 21*s.*, and the cheaper grades could be secured as low as 14*s.* Cokes were, however, scarce and steady round 60*s.*, with gas coke firm at 36*s.* Patent fuel was in little demand, and sellers experienced difficulty in securing the quoted prices of 33*s.* to 34*s.* Exports of coal as cargo in the week ended Friday last amounted to 581,380 tons, compared with 582,000 tons in the previous week. Of last week's total, 288,000 tons were shipped from Cardiff, 92,900 tons from Newport, 61,300 tons from Swansea, 121,100 tons from Port Talbot, and 18,400 tons from Llanelly. Shipments to France amounted to 256,700 tons, Italy 70,600 tons, South America 68,300 tons, Spain 26,200 tons, Portugal 23,400 tons, Greece 14,800 tons, British coaling depots 43,600 tons, Canada 1,600 tons, Belgium 19,500 tons, Holland 19,000 tons, Germany 17,700 tons, and other countries 20,200 tons. Exports of patent fuel totalled 24,300 tons, against 23,500 tons, and coke 9,400 tons, compared with 6,000 tons.

Westville Shipping Company.—The liquidator of the Westville Shipping Company, Limited, Cardiff, in voluntary liquidation, in convening a general meeting of shareholders for the purpose of receiving his account, states that as the company was insolvent there will be no return to the shareholders. The Westville Company was formed in 1919 and owned three steamers, the Polly Bridge, Avanville and Shoreham, which were sold by the company's bankers to a Liverpool firm.

Iron and Steel.—There is practically no change in the position of the Welsh tinplate trade. Outputs will, of course, be affected by the annual week's holiday which the workmen are taking this week and, as a result, there may be a slight increase in prices next week. Buying, however, is of a hand-to-mouth character, and there is practically no prospect of the official minimum of 23*s.* 1½*d.* basis, *i.e.*, f.o.b., being raised this side of October. Tin-plate bars are unchanged at 9*l.* 2*s.* 6*d.* per ton f.o.b., South Wales, less 7*s.* 6*d.* rebate to the tin works in the stabilisation scheme. Galvanised sheets are firm at 18*l.* 12*s.* 6*d.* to 18*l.* 15*s.* for 24-gauge corrugateds in bundles, and nickel is quiet at 130*l.* to 135*l.* per ton, with foreign metal 10*l.* lower.

CATALOGUES.

Thermometers.—A small pamphlet containing some clearly written notes in non-technical terms on the measurement of temperature comes from Messrs. Negretti and Zambra, 38, Holborn Viaduct, London, E.C. 1.

Steam Gauges.—An interesting booklet catalogue of their steam gauges, with description and instructions for fixing, comes from Messrs. Smith Brothers and Co. (Hyson), Limited, Nottingham.

Oil Engines.—A pamphlet of letters of testimonial from users of their small oil engines comes from Messrs. Marshall, Sons and Co., Limited, Gainsborough, including letters from owners of farms, creameries, bakeries, printing works, pumping works, &c.

Winding Machinery.—A 16-page catalogue of electrically driven winding machinery from the A.C.E.C. Company, of Belgium (London office, 56, Victoria-street, S.W. 1), gives a good description of the machines, with many illustrations.

Type-Setting Machines.—The "Intertype" composing and casting machine is of the kind in which a line of type moulds are selected and arranged by the compositor fingering a keyboard; the line is then cast and the moulds distributed, both the latter operations being automatic. A catalogue from Intertype, Limited, 15, Britannia-street, King's Cross, London, W.C. 1, states that the machine deals with type up to ½ in. deep per line full face, or ⅝ths in. narrow face, and shows examples of display advertisements and other matter set on the machine.

Electrical Machines and Gear.—We have received a series of excellently arranged and printed catalogues dealing with: (i) Automatic oil break ironclad switch gear, (ii) flexible unit type of air break ironclad switch gear, (iii) panel type switchboards, (iv) sheet steel cubicle switchboards, direct-current commutating pole motors, (v) direct-current pole motors and generators, from the Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester. In all cases the technical and commercial information is excellent, and the illustrations present the main parts separately in addition to general views.

Gas Engines.—A new edition of the catalogue of gas engines made by Messrs. Tangyes, Limited, Birmingham, is of exceptional interest in its detailed illustrations and description of essential parts and the very clean and compact outlines of the general design shown. There are 15 standard sizes, of powers ranging from 25 b.h.p. to 245 b.h.p. for town gas; and these are in two series for (*a*) general work, and (*b*) electric lighting. The two series are repeated for suction gas giving somewhat less powers. Both are again repeated as coupled engines of doubled powers, so that there is a very ample selection, including the choice of single or double engines for the powers between 50 b.h.p. and 250 b.h.p., or thereabouts.

PROHIBITED DRILLS IN GOLD MINES.—We read in *The South African Mining and Engineering Journal*, that as a result of the protracted negotiations that have been proceeding regarding dust-making drills, the Government mining engineer has now issued an official notice prohibiting the use of certain drills. These are: The short piston Leyner drill, in all development work except shafts and winzes, after the 10th day of March, 1924; and the model 21 Waugh turbo drill (standard), in all classes of work, after the 10th day of January, 1924. In both cases, of course, the makers have been officially notified some time ago of the threatened prohibition, and they have taken steps to put improved drills on the market. The Denver rock drill concern have introduced model 21A improved Waugh turbo, which has satisfactorily passed the dust tests and been recognised by the Mines Department.

NOTICE OF MEETING.

THE MINING INSTITUTE OF SCOTLAND.—Saturday, August 11, at 3 p.m., at the Royal Technical College, George-street, Glasgow. "Tacheometry as a Method of Underground Surveying," by Professor H. Briggs, D.Sc., and Mr. James Cooper, F.R.S.E.; "Economy and Sufficiency in Ventilation," by Mr. Joseph Parker, B.Sc.

UNIVERSITY OF BRISTOL.—We have received from the Faculty of Engineering, which is provided and maintained by the Society of Merchant Venturers in the Merchant Venturers' Technical College, Bristol, a prospectus for the session 1923–24. Courses of study are available at the college for persons intending to engage in civil, mechanical, electrical or automobile engineering, and particulars of these courses are given in the prospectus. The ordinances and regulations relating to degrees and diplomas in engineering subjects are included, with particulars of the Bristol sandwich system of training engineers. The prospectus can be obtained from the Registrar of the Merchant Venturers' Technical College, Bristol.

BRICKS FROM GOLD MINE DUMPS.—It is believed that at last the mine dumps will be turned to commercial use in the manufacture of bricks, according to *The South African Mining and Engineering Journal*. Some time ago Mr. W. Ingham, chief engineer to the Rand Water Board, caused to be sent oversea, for testing in plant that has produced lime sand brick for actual buildings, hermetically sealed samples of sand from the dumps of the George Goch, Ferreira and Robinson Deep Mines, together with quantities of white and blue lime from the Northern Lime Company and the Ventersdorp Company. The sands were first freed from all trace of cyanide. Mr. W. Arnott, engineer, of Glasgow, took these samples of sand and lime to the Continent and there personally inspected the process. As a result, samples of bricks have reached Johannesburg, and it is claimed that they are as satisfactory as faced bricks at a low cost. They are hard, and grey-white in colour. They have been inspected with great interest, and a company has been formed. It is stated that 56,000 of these bricks can be turned out per diem at a cost of 27*s.* 6*d.* per 1,000. In his report Mr. Arnott says the bricks "are better than the best clay bricks, and are justly known as hard bricks. A crushing resistance of over 4,000 lb. per square inch has been obtained, and a degree of hardness far surpassing clinker bricks."

MERCURY MINE IN KWEI-CHOW.—The mercury mine of Dong-shun-hsien, Kwei-chow, says the Chinese Government Bureau of Economic Information, has been in operation many years. If what the natives say is dependable, their ancestors were engaged in mercury mining in the Ming Dynasty (1368–1644). The veins are found in the limestone strata and in isolated patches or pockets. The methods used in opening the mine and in smelting the mineral are very poor and crude. In opening a mine holes are drilled to a certain depth, and into them 2 lb. or 3 lb. of gunpowder are introduced. The result of the explosion after the ignition of the gunpowder is 200 lb. to 300 lb. of mercury ore. After breaking up the rocks into small particles, these are put into the native furnace for smelting. The furnace consists of three boilers and one earthenware basin. Over the brick foundation of the furnace the first boiler is placed and the second boiler upside down on the first, a 12-in. hole being made in its centre. The second boiler is covered with mud held in place by a bamboo network and upon this the third boiler, also with a hole in the centre, is placed. This third boiler is then covered by an earthenware basin. After heating, the mercury is evaporated and condensed on the entire surface of the earthenware basin. This is rubbed off and put into bamboo tubes. The mercury obtained in this way is ready for sale.

THE FATIGUE LIMIT AND PROPORTIONALITY LIMIT OF MONEL METAL—ERRATUM.—By an unfortunate oversight two lines were omitted from the note on this subject which appeared in our issue of July 20, 1923. Near the bottom of page 88, middle column, the text should run as follows:—"With steel, there is found to be a very fair correlation between the endurance limit of the material and the Brinell test, and this appears to hold also with Monel metal. There is no such correlation between the proportionality limit and the Brinell test. Thus, with a series of 9 specimens in which the proportionality limit ranged from 10·3 up to 29·2 tons per sq. in., the range of Brinell numbers was from 163 up to 217." The point it was intended to make was that, as there was no correlation between the proportionality limit and the Brinell test, none was to be expected between the proportionality limit and the endurance limit. In this connection the following quotation from *The University of Illinois Bulletin*, vol. xx, No. 37, page 55, is of interest:—"In a letter from one of the engineers of the British National Physical Laboratory it is stated that the correlation between fatigue strength and Brinell hardness has been observed there for some years, and that in the determination of the fatigue strength of a metal it is customary to use the Brinell test to get an approximate idea of the endurance limit." Additional corrections required are the insertion of the word "limit" after the word "proportionality" in the title of the article, and in the second column of the table, near the end of the article, $2 \cdot 3 = 10^6$ should read $2 \cdot 3 \times 10^6$.

30-CWT. TALBOT SUBSIDY MOTOR LORRY.

CONSTRUCTED BY MESSRS. CLEMENT-TALBOT, LIMITED, ENGINEERS, LONDON.

(*For Description, see Page* 174.)

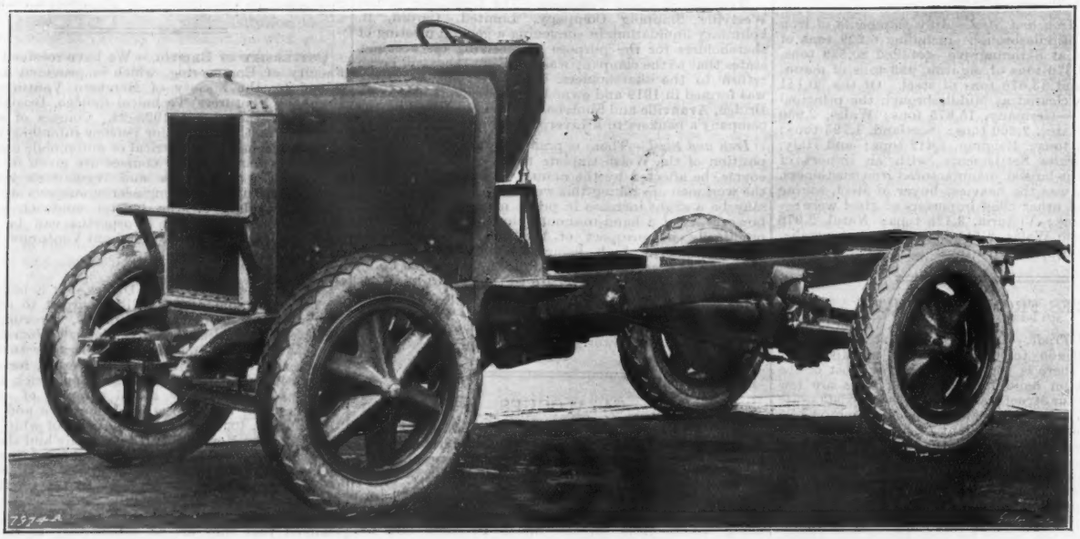


Fig. 1. Chassis Complete.

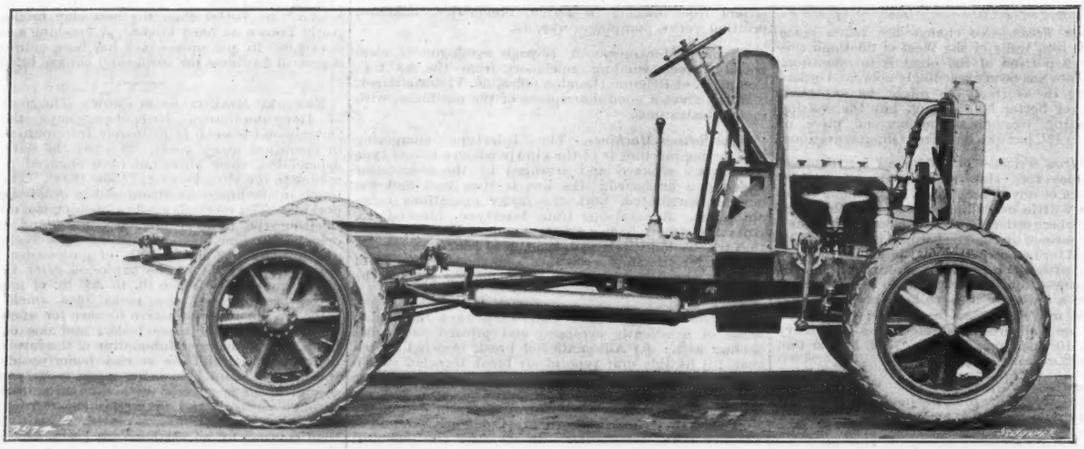


Fig. 2. Chassis with Bonnet Removed.

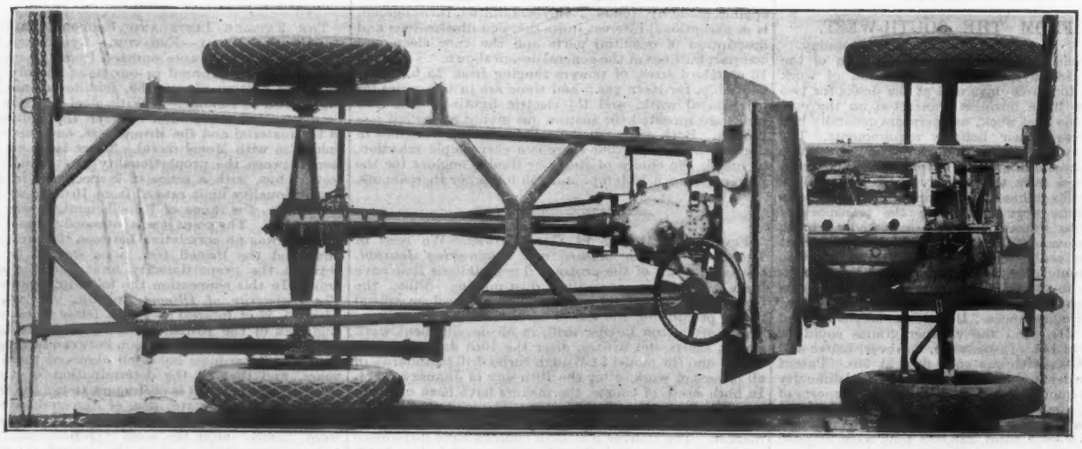


Fig. 3. View of Chassis from Above.

30-CWT. TALBOT SUBSIDY MOTOR LORRY.

CONSTRUCTED BY MESSRS. CLEMENT-TALBOT, LIMITED, ENGINEERS, LONDON.

(*For Description, see Page* 174.)

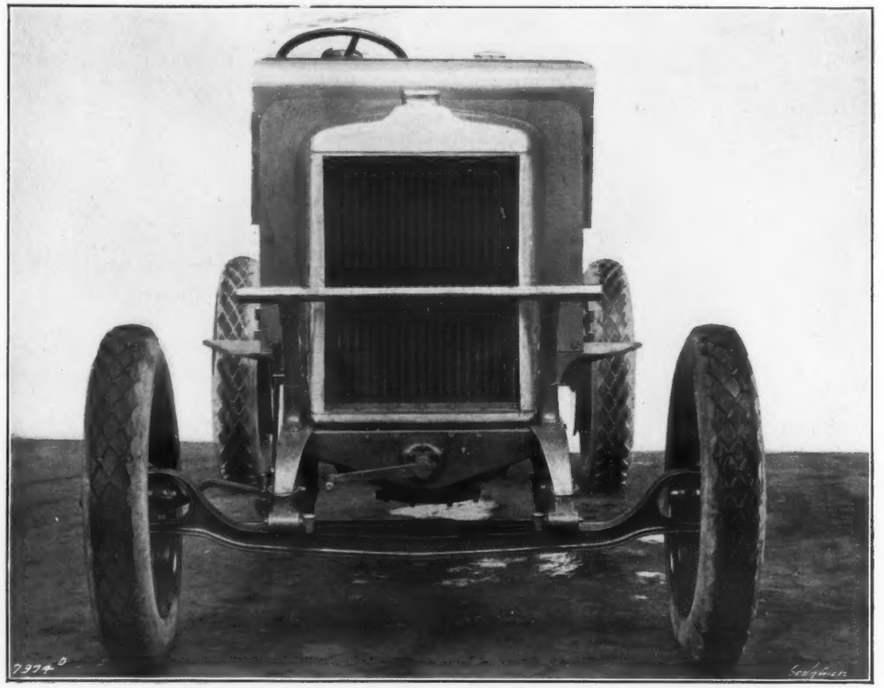


FIG. 4. FRONT VIEW OF CHASSIS.

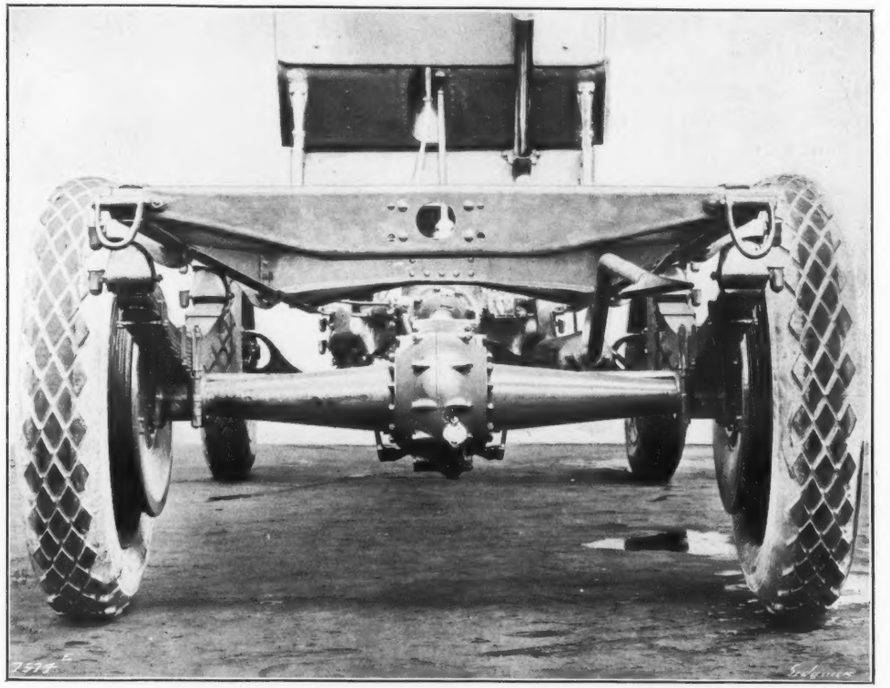
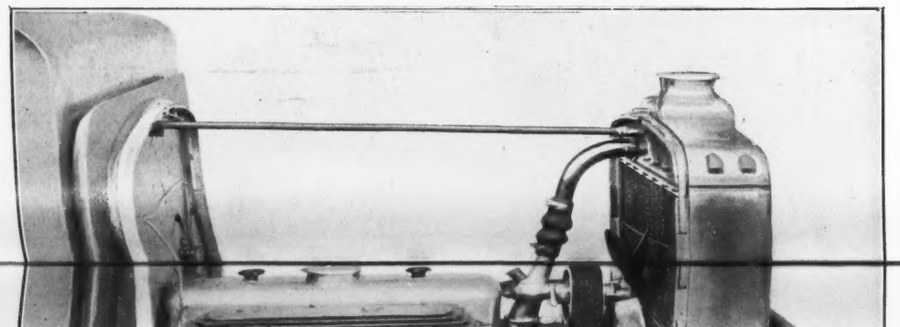
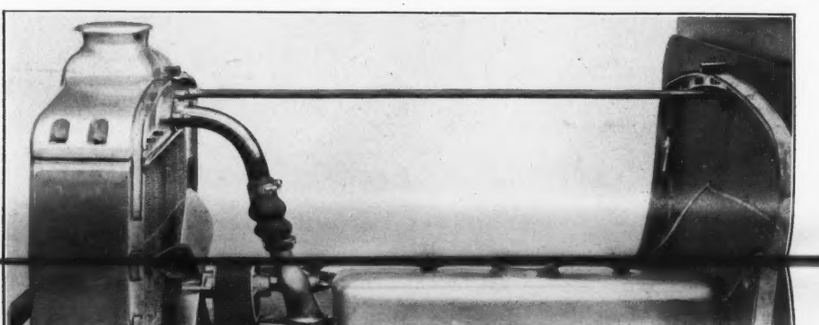


FIG. 5. REAR VIEW OF CHASSIS.





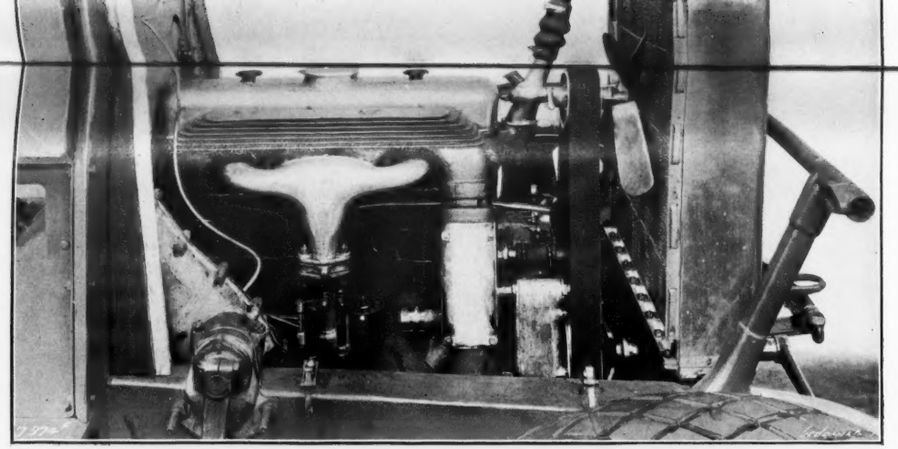


Fig. 6. Engine, Off Side.

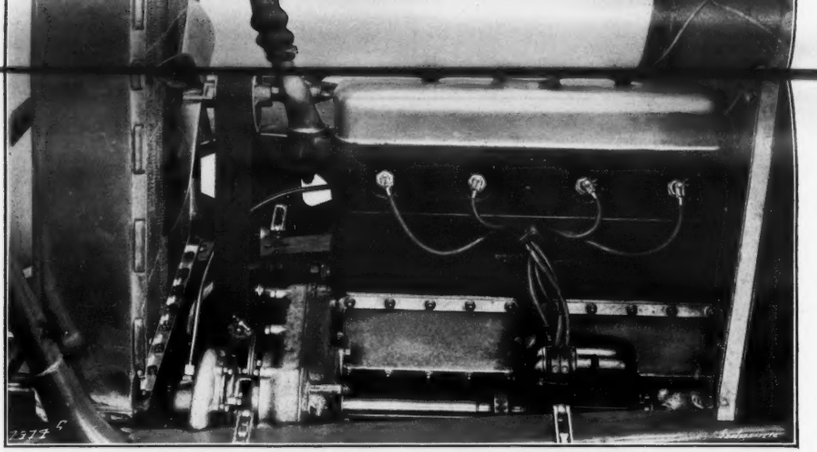


Fig. 7. Engine, Near Side.

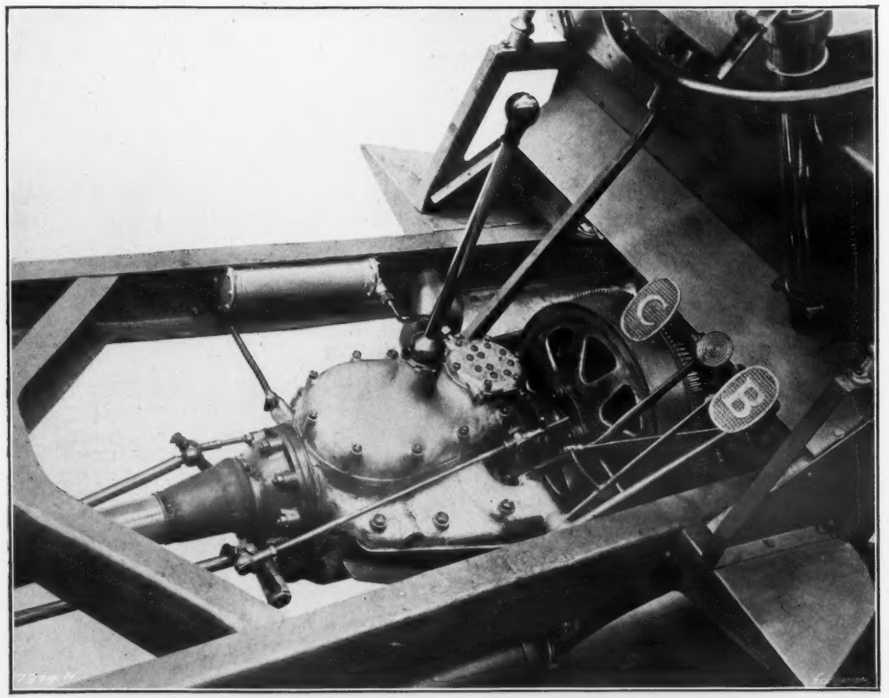


Fig. 8. View Showing Gear-Box and Clutch.

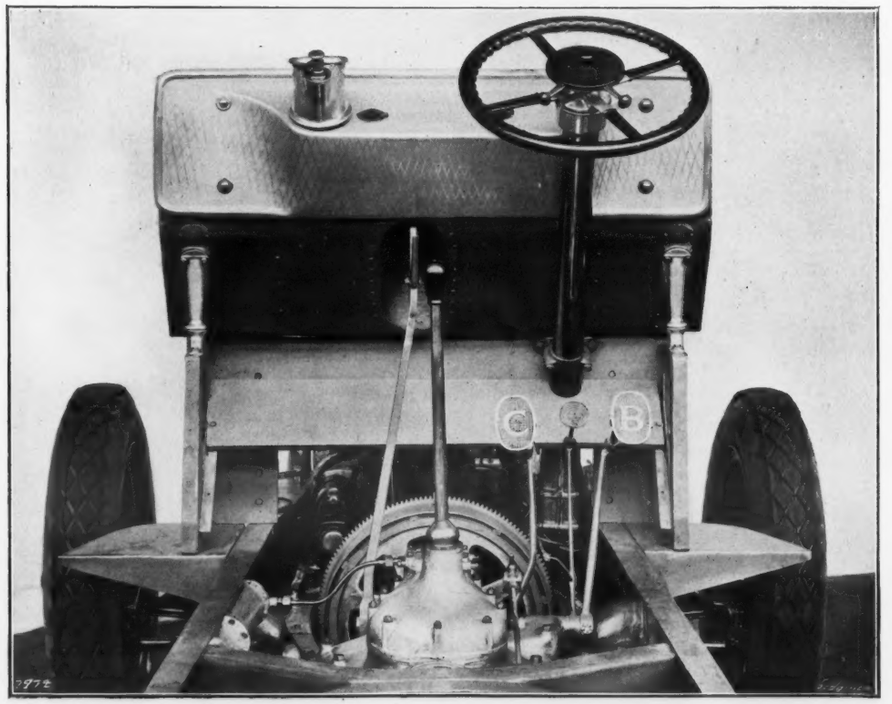


Fig. 9. View Showing Dashboard and Controls.

ENGINEERING.

Offices for Publication and Advertisements, 35 and 36, Bedford Street, Strand, London, W.C.2.

We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

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TELEPHONE NUMBERS—3663 and 8598 GERRARD.

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When foreign subscriptions are sent by Post Office Orders, advice should be sent to the Publisher.

ADVERTISEMENT RATES.

The charge for advertisements classified under the Headings of Appointments Open, Situations Wanted, Tenders, &c., is four shillings for the first four lines or under, and one shilling per line up to one inch. The line averages seven words. When an advertisement measures an inch or more the charge is 12*s.* per inch. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

TIME FOR RECEIPT OF ADVERTISEMENTS.

Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity of going to press early with a portion of the edition, alterations for standing advertisements should be received on the Friday previous to the day of publication.

All accounts are payable to ENGINEERING, LTD. Cheques should be crossed "The National Provincial and Union Bank of England, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford-street, Strand, W.C. 2.

AGENTS FOR "ENGINEERING."

AUSTRALIA: Gordon and Gotch, Limited, Melbourne; Sydney; Brisbane; Perth. Angus and Robertson, Limited, Sydney, N.S.W. T. Willmett and Co., Townsville, North Queensland. W. C. Rigby, Adelaide, South Australia. Melville and Mullen, Melbourne, Victoria.

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SOUTH AFRICA: Central News Agency, Limited, Head Office—Johannesburg; and Pretoria, Cape Town, Port Elizabeth, Bloomfontein, Durban, and their various branches and bookstalls throughout South Africa. Also Wm. Dawson and Sons (South Africa), Limited, 29 and 31, Long-street, Capetown.

TASMANIA: Gordon and Gotch Proprietary, Limited, Launceston; Hobart.

UNITED STATES: For subscription, New York; W. H. Wiley 432, Fourth Avenue. For Advertisements: J. S. Allan 30, Church-street, New York.

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Two-Page Plate.—30-*CWT. TALBOT SUBSIDY MOTOR LORRY.*

ENGINEERING.

FRIDAY, AUGUST 10, 1923.

FACTORIES AND WORKSHOPS IN 1922.

BOTH leading members of the Government and the professional pessimists of the official opposition have given forth dismal forebodings as to our trade prospects in the immediate future. Some, with that easy and popular style of logic which confuses casual co-existence with causation, affirm that all our present and prospective evils are attributable to the Ruhr occupation, whilst others with, we fear, a deeper insight into essentials, threaten us with far worse times when the vast sums expended since the armistice in developing the resources and improving the plant of this industrial area are allowed to come to full fruition. It is some relief to find that less gloomy anticipations are expressed in the report* just issued by the Home Office dealing with the record of our factories and workshops for 1922. Writing on May 15 last, the Chief Inspector states that, although trade and conditions have remained at a very low ebb, the reports received indicate a turn in the tide and a gradual revival in some of the more important industries. Many additional blast furnaces are in operation, though it is to be feared that the refusal of the boilermakers to keep faith may occasion a set-back. It is also gratifying to note that whilst the depressing conditions have caused many manufacturers to suspend new outlay on plant, others have considered that the quiet times have provided a long-awaited opportunity for modernising their equipment. The wealthy German industrialists, therefore, may not have matters all their own way even if they do succeed in evading their just obligations.

The report states that improvements effected in steel works in the North Eastern district have made it possible to operate 160-ton steel furnaces with but three men, and that a rolling mill turning out 1,500 tons of rails per 24 hours is operated during each shift by a crew of four men only. It will be remembered that visitors to the United States in the old days were struck by the deserted appearance of the Carnegie works, the equipment of which was such that the tonnage production per head was far in excess of what was common here. From what has been said above, it would seem that our past handicap in this regard is disappearing, and for this a word of appreciation is due to the unions concerned, who in the steel trade seem to be much less intransigeant in the matter of improved appliances than is customary elsewhere.

It is no doubt true that engineering trade unions declare that they are not opposed to the introduction of better machines, but in many instances cross-examination has elicited the all-important proviso that there must be no consequent reduction of labour costs. It ought, however, to be added that great improvements are also reported in the mechanical equipment of shipyards. We have held our own in shipbuilding largely through the exceptional skill of our men, but, as experience in the boot trade has shown, the individual skill of the operative may at any time be more than offset by the introduction of improved appliances, and it is satisfactory to learn that our builders are recognising this danger. It is also gratifying to note that it is not merely matters of material and equipment that are receiving attention. More and more thought yearly is being devoted to increasing the safety of the operators. During the year a rolling mills agreement to this end has been arranged between the owners and operatives in the Sheffield area. Agreements of this kind, arranged in conference between the parties concerned, receive more than the benevolent patronage of the Home Office, and several have been negotiated, amongst which may be noted that relating to the guarding of wood-working machinery. In general these agreements embody nothing new, but simply bring up the general standard of safety to that already attained in the more progressive works. These, no doubt, will, as in the past, soon proceed to go one better; nevertheless the establishment of such a code does introduce a certain element of standardisation, and should lead in the end to a lessening of the cost of protecting machinery.

Machinery accidents are, however, responsible for only about one-third of the total. In 1922 some 98,000 accidents were recorded of which 68,500 were non-machinery accidents. The machinery accidents, however, include more than a proportionate number of really serious cases, and hence it is highly important that fencing and guarding should be steadily improved as experience makes possible. The commonest objection to guards is that they reduce output, and this drawback is urged both by owners and operatives. Indeed, the report emphasizes the importance of having guards so strong and so securely fixed that the attendant cannot easily break or remove them. It is interesting to note, therefore, that in the case of certain power presses the fitting of guards led to a substantial increase in output, due, it is thought, to the rhythmic swinging to and fro of the guard inducing the operative to keep step.

The safety committee movement appears to be progressing even if but slowly. Several instances are given in the engineering trades in which the special attention devoted to questions of safety have effected a very large reduction in the cost of compensation. Thus one Midland firm reports that, whilst in 1913 it paid 9*s.* 11½*d.* in compensation for every 100*l.* spent in wages, the cost last year was but 2*s.* 10*d.*, and it was even less in 1921. The National Employers' Mutual Insurance Association are taking a very active interest in these matters, and have appointed a special staff to study the question of accident prevention.

As usual, crane accidents have been serious, but it is very remarkable how few, relatively speaking, are due to chain failures. Theory indicates the existence of very high stresses in chain links, even under static loads, and in view of the liability to surges, these calculated stresses must often be exceeded, yet experience shows that chains, if properly looked after, show remarkable endurance. Out of a total of 409 accidents to power-operated gib cranes only 18 were due to failures of the sling, chain or hook. The larger firms are now insuring their cranes and having them periodically inspected; but, as usual, the small employer lags behind (in most cases, no doubt, involuntarily), although his cranes are specially apt to be operated

* Annual Report of the Chief Inspector of Factories and Workshops for the year 1922. [C.m.d. 1920.] H.M. Stationery Office. 1923. [Price 5*s.* net.]

by odd workmen. Some curious failures of wire ropes are reported. The ropes in question were used in an acid-contaminated atmosphere and proved to be badly corroded at the core, although the outer wires seemed in excellent condition.

Dock accidents have been numerous, 74 fatal and 4,975 non-fatal cases being recorded during the year. Of these, however, but 7 fatal and 31 non-fatal were due to breaches of the regulations. The inspectors, indeed, report that it is the elimination of hazardous practices which is the main requirement, and not so much an improvement in safeguarding standards. Some shipowners are eliminating one possibility of accident by providing special hatchways for the ladders by which access to the cargo is gained, and one shipping line has appointed a "safety engineer" specially charged with the prevention of accidents in the loading and unloading of cargoes.

In the section dealing with the hours of labour the report states that in spite of the introduction of the 44-48 hour week there have been relatively few offences in the nature of "time-cribbing" or of excessively long spells. Many of the infringements, moreover, are breaches of the letter and not of the spirit of the regulations, and attention is drawn to one illegal practice which is highly appreciated by the operatives concerned. Under the regulations no single spell must exceed five hours, and half an hour must elapse between successive spells. In certain cases, however, the owners, instead of having one half-hour break in the afternoon spell have given a quarter of an hour both morning and evening. This arrangement involves a breach of the regulations, but the operatives welcome the two breaks for tea, the more especially as in many cases their wages are not stopped for the quarter-hour intervals, but would be for a single half-hour interval.

It is a pity that the Acts do not allow a greater discretion to the inspectors. In last year's report another case was mentioned in which much inconvenience was caused by the cast-iron character of the rules. In this instance new works were laid out for 2,000 men and provision made in the mess-room to seat 1,000, as it was not anticipated that a larger fraction would wish to make use of the accommodation thus provided. It turned out, however, that three-fourths of the operatives resorted to the mess-room. The inconvenience could have been overcome had the regulations permitted different meal hours for different sections of the factory.

The reports as to the two-shift system vary widely. In some areas it is said to be enthusiastically approved by the operatives, whilst in other cases they merely reluctantly acquiesce. Its popularity or the reverse seems to depend largely on transport facilities, and in some cases firms have made special arrangements for returning to their homes those engaged on the second shift. No doubt the system is not equally applicable to all industries, and in any case its successful working involves specially capable management. The report mentions one firm in Essex who have four shifts in the 24 hours, and both owners and operatives are said to be, in this instance, well satisfied with the outcome.

The war led to statutory establishment of certain welfare provisions, but unless the firms concerned take a personal interest in the matter the results are not generally very satisfactory. The neglect to provide for adequate supervision soon reduces the mess-rooms, cloak-rooms, and other conveniences to a repulsive condition, but it is not the owners only who are at fault. The report states that during the war women replaced men in the oil-cake mills and proper provision was made for them. When the men returned and the women were ousted, there was wholesale destruction of the arrangements provided for the workmen's comfort, and in the end an appeal had to be made to the trade unions concerned. The report adds that as regards "voluntary welfare," the reports show that even in these days of enforced economy, schemes are being maintained. One firm has gone so far as to arrange that every employee, after a certain length of service, receives a weekly pension of 1*s.* for each year of service, and the scheme involves no contribution from the men.

The section of the report dealing with industrial diseases describes an interesting application of the principle of Aitkens' dust counter to the investigation of the state of the air in dusty trades. Dust is, no doubt, objectionable in any case, but it is the silica dust which is really dangerous, and especially particles less than 2 μ in diameter. In certain cement works the operation of sack filling has been rendered almost dust-free by the introduction of a vacuum process.

In the report on the electrical trades Mr. G. S. Ram brings forward evidence which gives some grounds for the belief that a violent mechanical shock aids recovery from an electric shock. He reports several instances in which after a bad electric shock the injured man has fallen through a considerable height, and eventually completely recovered. There have been, it appears, several fatal accidents with alternating current supplied at 250 volts, which seems to be distinctly more dangerous than direct current of the same nominal voltage.

It is not often that we find in these reports matter for adverse criticism. They are, in general, characterised both by knowledge and common sense. It is, however, difficult to see what practical end is served by such "researches" as those of the medical officer and an appointee of the Industrial Fatigue Research Board. The "research" in question deals with weight-carrying by women. The subjects of the experiment were totally inexperienced in weight-carrying, and it is difficult to see that the elaborate records taken, throw any light upon the question of what are and what are not excessive loads. In this matter experiment cannot pretend to vie with experience. Darwin has described how ore was raised from the Chilian gold mines which he visited in 1834–35. No lifting machinery was provided, and the ore was carried up by workmen in loads of 200 lb. The mine was 450 ft. deep, and not even proper ladders were provided, the men having to climb by putting their feet in notches cut in tree trunks. Even beardless young men of 18 or 20 took up these apparently excessive loads. Indeed, Darwin was informed that loads of as much as 300 lb. per man had thus been raised from the deepest mines. Data of real interest and importance have apparently been collected by Miss Taylor as to what loads are actually carried by women in tinplate works and elsewhere, but those which would be really informative have apparently for some unexplained reasons been held back from this report.

FRUIT STORAGE AND TRANSPORT.

Modern industrial practice is coming increasingly to recognise that few industries are self-contained and independent. Each has to look to others to supply its needs, or to consume its products as their raw materials. It must know the difficulties that have to be dealt with in production and in use, and the properties of materials by which these difficulties can best be met. Steel makers are seeking energetically to bring home to engineers not merely the names and merits of their brands but the scientific facts that determine and limit the properties of their products, while engineers are trying so to define their requirements that they can be satisfied without making difficult and therefore costly demands on the steel makers. Without and apart from formal alliances modern industries are finding, in fact, that this sort of co-operation, in which each industry tries to assimilate the point of view of the others with which it is connected, is among the most powerful means of making progress and economies, and those industries that have to use the services of engineers are learning to define their exact needs more accurately than was usual, and to explain them clearly to the engineers by whom the needs have to be satisfied.

All this means that engineers, fully burdened as they already are with the necessity of acquiring knowledge of various sorts, have continually to be adding to that knowledge, and it is useful from time to time to be able to point to a fresh example of knowledge apparently alien from their work which nevertheless has shown them how to increase their efficiency. Such an example is contained in the report just issued by the Food Investigation Board, dealing in effect with the genesis of a disease of apples and pears and the means of avoiding it.* The net result is to indicate purely physical means for increasing the safety of the fruits in question, and probably also of others, while in storage and transport; and the circumstances of the inquiry illustrate aptly how the examination of one problem may lead to the solution of another.

In the winter of 1918 the authors were seeking a cheap method for preserving the home-grown apple crop in storage, and for this purpose were investigating the effect of carbonic acid and subnormal oxygen in retarding the ripening of the fruit. In the course of their experiments some of the apples were found to have undergone a striking change. While externally they seemed to be good and sound, the interior, starting from the core outwards, had become brown and dead, with a typical appearance to which the authors gave the name of "brown heart." The disease could not be traced to infection by bacteria or moulds, but appeared to be a functional derangement, an interference of some kind with the apple's way of life or metabolism. A series of observations extending into 1919, 1920 and 1921, led to the conclusion that this disease was some kind of function of three variables, viz.: an excess of carbonic acid, an insufficient supply of oxygen, and unfavourable temperature. While these experiments were going on, trouble was being found on a large scale with whole cargoes of apples imported from Australasia, and in 1922 the Food Investigation Board was consulted as to the cause. On an examination of specimens of the affected fruit the disease in question seemed identical with that which had been identified by Dr. Kidd and Dr. West, and a more careful analysis was made of the apparent factors of the disease, with a detailed study of the respiration of the apple by which carbonic acid is produced. The present report gives the leading results obtained in these several investigations.

The earliest of these investigations was a series of storage trials made from 1919 to 1921, with the primary object of tracing the effect on ripening of high carbonic acid and low oxygen. In these apples in considerable numbers were stored, some in what are described as gastight containers, and the remainder as controls on shelves or trays in ordinary sheds or cellars. It was found that in gas-storage containers of all sizes, from a tenth of a cubic foot up to 50,000 cub. ft., no marked difference could be detected at any point in the relative proportions of carbonic acid, oxygen and nitrogen throughout the vessel, and it appears therefore that, independently of mass movements induced by convection, carbonic acid diffuses uniformly into the enclosed atmosphere practically as quickly as it is formed. Living fruit consumes oxygen rapidly, producing about an equal amount of carbonic acid, and accordingly the amount of carbonic acid and oxygen in the atmosphere of the storage chamber can be regulated at any time by simple ventilation. For experimental purposes a mixture of nitrogen and 21 per cent. carbonic acid was substituted occasionally for the ventilating air when through leakage or any other cause the amount of carbonic acid required by the experiment had not been produced, and it was therefore desired to increase it without disturbing the proportions of oxygen and nitrogen. Apparently the vessels were not always rigidly gastight, and sometimes permitted a certain amount of leakage, as in a badly ventilated hold, the essential point in the trials being that the carbonic acid and oxygen percentages were observed, and kept under control.

In the first of these trials, lasting from October to March, 1919–20, inclusive, part of a sample of a single variety of apples was kept in gas storage, ventilated from time to time through hand-regulated ports, and sub-samples were taken and stored in trays by the side of the remainder of the sample in the outhouse in which the gas-storage vessels were kept. The maximum carbonic acid percentage in storage (22·8 per cent.) was reached on the thirtieth day, the oxygen falling simultaneously to about 3 per cent. and throughout the trial varying

* "Brown Heart—A Functional Disease of Apples and Pears," by Franklin Kidd, D.Sc., and Cyril West, D.Sc.; H.M. Stationery Office.

inversely with the variations of carbonic acid; the temperatures varied between about 20 deg. and — 3 deg. C. When opened at the end of the trials, the control apples, which had not been in gas storage, were all sound both externally and internally, while all the gas-stored apples had developed brown heart, though remaining sound externally. Sub-samples, taken from gas storage after 44 days and 77 days and kept with the controls for the rest of the trials, had all developed brown heart; the disease had stopped short at a certain point—presumably when removed from the storage atmosphere—and the injured parts had dried up. In a similar trial the following year 65 per cent. of the gas-stored apples showed brown heart, all the controls remaining sound. Simultaneously with the first trial, four other varieties of apples were treated similarly for 217 days, the maximum carbonic acid percentage reached within 122 days being 16 per cent. As before, the controls remained sound, but so also did all the lots of three varieties of the gas-stored apples; all of the fourth variety developed brown heart, which appeared in the first sub-sample, taken after 122 days. The trials up to this point showed therefore that the appearance of the disease was associated with high carbonic acid and low oxygen, but that different varieties of apples varied considerably in their susceptibility to it. In further trials, made to test how subnormal oxygen and complete absence of oxygen affect ripening, brown heart appeared in three varieties out of four when the full carbonic acid concentration was permitted, but never when the carbonic acid was absorbed as fast as it was produced and the oxygen kept low, nor did it appear at all when the carbonic acid was absorbed as soon as the whole of the oxygen had disappeared and the ingress of further oxygen was practically stopped, though in the latter trial—practically no carbonic acid and no oxygen—the apples became unsound through "deep scald." It appeared, therefore, that on these apples mere absence of oxygen did not cause brown heart. In a final trial of 105 days, designed primarily to compare the effect of gas storage, cold storage and both together, apples stored at 8 deg. C., as well as controls stored in air, remained sound, while 70 per cent. of similar apples stored at 1 deg. C. developed brown heart, the maximum percentage of carbonic acid having been 18 per cent., except for a quite short interval of 22 per cent. in the cold store, and the minimum oxygen having been 5 per cent. A number of trials on pears gave similar results.

Assuming, therefore, that all apples would behave as the several varieties used in these trials, it was clear that, while neither a low percentage nor complete absence of oxygen would produce brown heart, carbonic acid above some limit coupled with an equivalent reduction of oxygen would, and that different varieties of apples had different susceptibilities to the disease. These conclusions left, however, a number of further questions to be determined, and under the pressure of the Australasian trouble, laboratory experiments were instituted to determine them. A preliminary investigation was made in the Botanical Laboratory at Cambridge on the "internal atmosphere" of apples, in which the air enclosed in certain microscopic canals that traverse the flesh of the fruit was analysed with what is described by Mr. W. B. Hardy, Sec.R.S., the Director of Food Investigation, as a high degree of experimental skill, though unhappily no details of method are given to be admired and imitated. From these it appears, as has been shown independently in the United States, that apples stored in a continuous supply of pure air evolve carbonic acid within themselves to an extent that not only varies with the variety of apple and the temperature of storage, but may also vary with different localities in which the same variety has been grown and constitutional differences have developed. Thus apples stored at 22·5 deg. C. contained 10 per cent. carbonic acid (the highest found in these experiments, though much less than was found in the American experiments on another variety of apple), while similar apples stored at 1 deg. C. contained only 1 per cent. As the ventilation of the interior of an apple is due mainly to diffusion, the maximum concentration of carbonic acid will presumably be at some distance from the surface or at points where the tissue cells are more compact or are "breathing" more rapidly. These several variations of internal atmosphere may serve to explain both the outbreak of brown heart from within and at isolated points, and also the differences in susceptibility between different varieties, an apple with high carbonic acid in its internal atmosphere requiring less carbonic acid in the outer air to determine the disease than one of which the internal carbonic acid is low.

The first series of direct experiments was made to determine whether carbonic acid in the absence of oxygen would cause brown heart in freshly-gathered apples stored at 1 deg., 8 deg. and 15 deg. C. The apples were stored in airtight glass containers, with saturated salt solution at the bottom to prevent the enclosed atmosphere from becoming saturated with water vapour; the air was swept out with a current of nitrogen, and the carbonic acid produced by the fruit was allowed to accumulate to between 30 per cent. and 40 per cent., when the container was again ventilated with nitrogen. Without exception none of the apples showed brown heart, indicating that carbonic acid could not cause it in the absence of oxygen, but all showed severe "deep scald." In a second series the same arrangements were repeated except that a 20 per cent. caustic soda solution was used instead of saturated salt solution, so absorbing the carbonic acid as fast as it was formed. The results were the same as in the first series, and as indeed had been found in the gas-storage trials; showing that absence of oxygen could not cause brown heart, though it could cause "deep scald."

A third series was designed to show the effect of different storage temperatures on apples stored in gastight chambers without any ventilation. Here the apples would at first absorb the oxygen and evolve carbonic acid, and thereafter evolve carbonic acid in the absence of oxygen. By the foregoing results these conditions could only cause brown heart at some time during the first stage, after the carbonic acid had reached the danger level for the temperature in question and before its formation had used up all the oxygen, and then only if the danger point had been reached sufficiently long before the exhaustion of the oxygen to give an exposure of the necessary length to the necessary carbonic acid concentration. The epoch and duration of this danger period depended on the temperature and the ratio of the volume of the air in the container to that of the apples. The apples studied were two lots of a single variety from different localities. About 15 of each, occupying half the volume of the air left in the container, were stored for 24 hours at 20 deg., and after four days' ventilation, so applied as to keep about the same constant percentage of carbonic acid in all three containers, were kept for the remaining 47 days of the test without any ventilation at all and at 1 deg., 8 deg., and 15 deg. C. respectively, the conditions of the preliminary 24 hours and 4 days having been due to a change in the original scheme of experiment. A carbonic acid percentage of 14 per cent. was reached on the first day, rising to 45 per cent. at 15 deg. on the 11th day, 37·5 per cent. at 8 deg. on the 13th day, and 28·7 per cent. at 1 deg. on the 14th day. At 15 deg. the oxygen had all disappeared after 11 days, and at 8 deg. after 15 days, the carbonic acid being then 45 per cent. in each case, while at 1 deg. the oxygen had disappeared on the 19th day with a carbonic acid percentage of 35 per cent. Little or no brown heart developed at 15 deg., but at 8 deg. and 1 deg. pronounced brown heart was evident, the extent of which was found by examination at the end of the test not to have increased after the oxygen had been used up. "Deep scald" on the other hand increased both with carbonic acid concentration and with time of exposure, irrespective of the oxygen. The apples from different localities showed different susceptibilities, 10 per cent. of one lot being affected by brown heart after three weeks at 15 deg. as against none of the other lot; at 8 deg. after four weeks 50 per cent. against 15, and at 1 deg. after seven weeks 60 per cent. against 25.

In these tests low storage temperatures were thus shown to be more favourable to brown heart than high, and the presence of some oxygen was again shown to be indispensable to the occurrence of the disease. To test whether ripeness affected susceptibility this series was repeated six months later with similar apples that had been kept in cold storage in the interval; these proved to be far less susceptible than they had been at the earlier stage of their storage life. In a later series of experiments on another variety of apples the same greater susceptibility of the less ripe fruit was shown; it appeared also that in the presence of enough carbonic acid to cause the disease (in these experiments attaining about 25 per cent. at 1 deg. C. in four weeks) high concentration of oxygen (from 100 per cent. to 28 per cent.) made no difference whatever in its extent. By another series of experiments, conducted with one variety of apples from two different localities, it was shown that these apples consumed at 1 deg. C. about 1 per cent. of the oxygen present and at 8 deg. C. about 2 per cent.; that both at 1 deg. and 8 deg. the apples from one locality stood 15 per cent. to 16 per cent. carbonic acid with 5 per cent. to 6 per cent. oxygen, while those from the other locality just showed a trace of brown heart, and with higher concentrations of carbonic acid they showed brown heart in all cases; and that although at the lower temperature the internal atmosphere of the fruit had a less carbonic acid concentration, more brown heart was produced than at the higher temperature. The lowest concentration found experimentally in association with brown heart of apples under gas storage was 13·6 per cent. The disease was also shown to have been produced under the conditions of experiment in less than three weeks; probably in considerably less. The extent of damage increased with the time of exposure; it is to be observed that in these experiments the percentage of carbonic acid also increased. By a final series of experiments it was found that exposure for 20 hours to 24 hours in pure air to a temperature of 45 deg. C. (it is not said whether with or without ventilation) determined the disease in apples from both localities. The results in regard to brown heart suggested an explanation of other diseases as well.

In the light of these results the out-turn of the Australasian cargoes examined in 1922 was immediately intelligible. They came on three ships, none of them with any definite provision for ventilation, but two provided with a forced circulation of the atmosphere of the holds, which must have considerably intensified the accidental ventilation arising from leakage. All three ships had cooling arrangements by brine pipes in the holds.

In the ship without forced ventilation there were three holds, each divided into 'tween decks and lower deck, and the atmosphere of each hold was sampled in both 'tween decks and lower deck compartments before discharge. Where the fruit had been precooled before loading the carbonic acid percentages were 2 per cent. to 18 per cent. respectively, and no brown heart was found. In one compartment, containing fruit that had not been pre-cooled, it was 3·7 per cent., and also free from brown heart. In each of the three others, also containing not pre-cooled apples, it varied from 30 per cent. to 38·5 per cent., and brown heart was found, in two holds severely. In the other two ships the carbonic acid concentration varied from 0·5 per cent. to 4·5 per cent., and no brown heart was observed.

On these facts it was concluded that at any temperatures likely to be found in holds, brown heart is a disease resulting in all cases from inadequate ventilation, and that by adopting means for controlling the concentration of carbonic acid in the holds it would certainly be possible to prevent the occurrence of this disease, and by giving appropriate values to the carbonic acid and oxygen concentrations it might also be possible in overseas transport to supplement the retarding effect of low temperatures on the ripening of fruit. Assuming that the holds were ventilated as economically as possible—that is, by admitting air periodically for short periods in such a way as to displace the hold gases without mixing with them—a calculation is given for the approximate amount of ventilation required in a hold of 50,000 cub. ft. capacity. From measurements made on one of the ships examined and its cargo it appeared that the apples themselves occupied not more than the volume of the atmosphere of the hold after the cases had been stowed.

The rate of carbonic acid production at a given temperature varies somewhat, as has been seen, with the variety of apples, its ripeness, and other factors. Using, however maximum values obtained by the authors and in the United States Department of Agriculture, it takes not less than 14 days at 34 deg. F., 7½ days at 50 deg. F. and 40 hours at 70 deg. F. to produce a volume of carbonic acid equal to that of the apples themselves. In a fully-loaded gastight hold the maximum carbonic acid to be expected per hour at these respective temperatures would be 0·25 per cent., 0·5 per cent. and 2·25 per cent., involving for a maintained concentration of 5 per cent. 1,250 cub. ft., 2,500 cub. ft. and 10,000 cub. ft. of air to be displaced from the hold per hour at the above respective temperatures, and for a concentration of 10 per cent. 600 cub. ft., 1,250 cub. ft. and 5,000 cub. ft. The extent of precipitation involved in introducing this volume of air into a hold maintained at a little below freezing-point would also be small; with air at 70 deg. F. and 80 per cent. saturation the amount required in a voyage of six weeks to keep the carbonic acid down to 5 per cent. would be from ¼ ton to ½ ton for a hold of 50,000 cub. ft. capacity. No doubt some considerable addition would have to be made to these figures for mixture of the ventilating air with that which it displaced.

It is therefore suggested that the atmosphere of holds should be controlled by suitable carbonic acid indicators, and that the amount of ventilation from time to time during the voyage should be regulated according to the readings of such indicators, just as the brine circulation employed for maintaining a constant temperature is regulated by thermometer readings. It is thought likely that for delaying ripening the method might also be applicable to soft fruits, and a table is given showing the carbonic acid concentrations on arrival in holds of vessels containing soft fruits shipped from South Africa, which varied from 1 per cent. to 10 per cent. It is observed however, that in the meantime pre-cooling lessens the danger of excessive concentration, and that an extended investigation should be made into hold atmospheres throughout the voyage, especially of closed unventilated holds, to explain the wide differences that sometimes occur between the carbonic acid concentrations in different holds.

THE RESISTANCE OF CONCRETE TO WEAR.

In modern factory buildings trouble often arises from the wear of the concrete floors. This takes place most commonly at points where trucking concentrates, such as doorways, alleyways, &c., but not infrequently extends over larger areas if the lots moved are moderately heavy and the truck wheels small. We are not considering the general proposition as to whether in itself concrete forms a good shop floor. The answer to that must depend to a large extent upon the class of work done in the building. We are accepting for the moment the fact that concrete floors exist, and are likely to persist in use, though for many cases there are much stronger arguments for other surfaces. In many cases in which wear, such as that to which we refer, has been experienced, the trouble has been overcome by adopting rubber tyres, instead of steel, for the truck wheels. If these in their service have to pass over heated surfaces, or approach close to furnaces they will be liable to damage, and the solution would then appear to lie in the direction of surfacing the concrete with a renewable coating which could be varied according to the locality. The shop floor could be laid with wood or asphalt, retaining concrete only for the neighbourhood of the small furnaces and so on. The idea, as in the case with roads, is to introduce some resilient material between the weight-carrying concrete and the load on the wheel. This can be either laid on the floor or attached to the wheels. The latter method virtually amounts to the old invention of a machine laying its own track.

The same problem faces the road authorities. It is the general opinion among road engineers in this country that if the use of steel-tyred, heavy vehicles could be reduced, the advantages of the concrete road would be very much greater. In America where experience with such roads has been considerable, the proportion of rubber-tyred vehicles is higher and the loads are generally lighter than with us, but even there, where traffic concentrates, the tendency is to adopt some surfacing material less subject to attrition. In recent years the adoption of rubber tyres has been more general over here, but the proportion of heavy loads on steel tyres is still high, and the ideal tyre for these can hardly be said to be with us yet.

In the concrete itself, and in its manufacture, whether for floors in buildings or for road surfaces there are many controllable factors which influence the resistance of the material to wear. The road engineer from the start has realised the need of obtaining good resisting qualities, but it is probable that in the case of many factory floors little heed has been paid during construction to points other than those relating to the strength of the monolithic structure, and a conventional top finish. In most circumstances the quality of a good concrete is appraised by its strength, whether strength is the actual quality required for some particular work or not. It appears that those factors, which, when suitably regulated, are in concrete conducive to high strength, are generally also favourable to high resistance to wear. Thus the importance, if strength is required, of restricting the water used in mixing to just the amount required to produce the proper consistency of mixture, has long been recognised over here, though in the United States it was common to use much wetter mixtures than were actually necessary. This factor is found to affect the wear of concrete in a parallel manner. Again, the increase of strength with time has long been recognised. Similarly the resistance to wear is improved by curing.

A brief summary of these factors is given in a paper by Professor Duff A. Abrams published by the Structural Research Laboratory of the Lewis Institute, Chicago. This summary is based upon a comprehensive series of tests made at the laboratory, and reported upon in a paper presented some time ago to the American Society for Testing Materials. The tests are of interest because they covered a great deal of ground in a very systematic manner. The subject is one on which text books are singularly silent, so that this ordered information is valuable in spite of the fact that it is rather qualitative than quantitative. These tests were carried out with a Talbot-Jones rattler, a machine consisting of a revolving horizontal cylinder, the interior walls of which are lined with blocks of the material to be tested. The cylinder is 36 in. in diameter, and the usual sized block is 8 in. by 8 in. by 5 in. thick. These are arranged so that the ring of 8 in. by 8 in. faces forms a 10-sided polygon inside the cylinder. The machine is loaded with steel balls, the standard in these tests being ten 3¾-in. balls and one hundred and thirty-five 1⅝-in. balls, weighing together 200 lb. The usual test consisted of running this tumbler at the rate of 30 r.p.m. for 900 revolutions in one direction followed by the same in the opposite sense. The blocks were weighed before and after the test, and the loss of weight taken as a measure of the wear. It may be questioned whether this gives an absolute measure of attrition, since it is probable the pulverising action is reduced in the later stages of the test by the accumulation of dust in the machine. While the final figures for tests similarly conducted are instructive, therefore, the actual effect of wear probably exceeds that indicated in the case of the more easily destroyed specimens. This seems to be confirmed by the fact that 3,000 revolutions gave a wear 88 per cent. higher than the standard 1,800 revolution test. About 10,000 blocks were tested covering investigations into the effect of quantity of mixing water, quantity of cement, grading of aggregate, comparison of different aggregates, the relation of strength to wear, and the influence of age, of time of mixing and of curing conditions.

The importance of using the proper amount of mixing water and no more, was clearly brought out in both the wear tests and comparative strength tests. These showed quite plainly that for a 1 : 4 mixture of cement and aggregate graded up to 1½ in., the best volume of water to use was 0·8 of the volume of the cement in the batch. This gave the required relative consistency with good strength and resistance to wear, though a concrete showing up rather better still can be made with less water than this. The actual best appeared to be a proportion of water of 0·7 to the volume of cement, but this gave a consistency of only 0·95 which is lower than is desirable for working. Now that batch mixing and mechanical mixers are generally employed, there should be no difficulty in regulating the amount of water used to the quantity actually required, even with unskilled labour. The experience and skill required formerly with manual labour is thus not so necessary on large work, but for small jobs and patching, for which it would be uneconomical to haul a mixer, the work should clearly be in rather more skilled hands.

A variety of aggregates was used in tests to determine the effect of varying the amount of cement in the concrete. These included sand with pebbles, or with crushed limestone, crushed slag and crushed granite. The tests covered mixtures ranging from 1 : 6 to 1 : 1. In the poor mixtures of 1 : 6 the wear in all cases was high. It fell rapidly to about 1 : 2, thereafter continuing to fall, but at a decreasing rate. In another series of tests the shape of the resulting curve was less definite as regards the point of transition from high to low wearing effects, but the trend was in the same sense, viz., indicating a reduction in the improvement with the richer mixtures beyond some economic point.

Curing tests showed definitely the advantage of maintaining the concrete moist for a period if good wearing qualities are required. The blocks were in this case all tested three months after casting. In one set of tests the period indicated would seem to be about 20 days to 30 days, while in others it ran as high as 40 days to 50 days. After the period mentioned there was no further improvement. The very valuable effect produced in the first few days is a particular feature of the results of these tests.

The grading of the aggregate indicated that up to a certain limit the coarser the aggregate the lower the wear. These tests are difficult to summarise, but we may give two instances of 1 : 4 mixtures of cement and aggregate. With sand and crushed granite the least wear was shown with 20 per cent. aggregate up to ⅜ in. size, 20 per cent. between ⅜ in. and ¾ in. and 60 per cent. ¾ in. to 1½ in. size. With crushed limestone the best proportions would appear to demand the rather larger use of the coarse at the expense of the intermediate grade. The grading may, however, vary over a wide range without affecting the results appreciably, while the wear of concrete does not depend so much upon the character of the coarser aggregate as is commonly supposed. The proper grading has much more influence according to these tests than the class of aggregate. The best results from the point of view of wear were obtained with granite, although sometimes considered not an altogether satisfactory class of material and not showing up in the strength test above the average. Blast furnace slag and limestone with the most suitable gradings gave results as good as those for granite, but the falling off with other proportions was greater than for granite. In the matter of aggregates it may not be out of place to remark that the rattler test with balls may not bring out quite all the points of service in connection with roads. Part of the danger to road surfaces lies in the fact that iron shod horse traffic may break and dislodge large pieces of aggregate on the surface. From such a point deterioration may spread rapidly, and for this reason a smaller aggregate is preferred for the top layer.

As regards the fine aggregate the quality of the concrete did not appear to be affected so long as this was structurally sound and clean, and did not contain an excess of very fine material, while the presence of hydrated lime or other admixtures up to about 20 per cent. did not seem to result in any deterioration of the wearing qualities.

Two of the most important series of tests had reference to age and time of mixing. It is well known that up to a point the strength of concrete increases with age, the improvement being very marked in the early stages. The curves for wear show a similar change. In these tests the specimens were cured moist for 14 days. The wear found at

21 days old, was reduced to three-fourths at 28 days old, while at about six weeks or two months the concrete had attained its best and final value, so far as wear was concerned. The importance of giving floors and road surfaces time to acquire full wearing qualities is thus clearly emphasised. Needless to say this is recognised as one of the factors which road engineers find it most difficult to arrange for, as it either requires the complete closing of a road for two months, or the concentration during that period of the whole of the traffic on the other half. This has often led to the complete failure of that section.

Now that mechanical mixers are used so largely the work done in mixing can be regulated to a nicety. The drum can be run at a steady speed and discharged after the proper amount of mixing so that uniform batches can be easily turned out for long spells together. In some cases this is so far recognised that makers will recommend to purchasers the best number of revolutions, but this is not suitable for all mixtures. It is to be presumed also that the mixing efficiency of different designs of drums would have a bearing on this, and it would be interesting if this point could be tested. The tests we are now dealing with clearly indicated the influence of mixing time on wear. Commencing with a very bad wearing concrete with a mix of under a minute, the qualities improved very rapidly up till 2 minutes, after which no gain was observable. Though shorter times are frequently claimed, this would therefore seem to be the limit to which the mixing time should be reduced. To lengthen it would probably produce no gain, but only a reduction of output, which is naturally to be avoided.

RAILWAY ACCIDENTS IN GREAT BRITAIN.

THE returns of the railway accidents in Great Britain, given in the report of Colonel J. W. Pringle to the Ministry of Transport, published last week now omit all reference to the railways of Ireland, except in so far as they contribute to the official average figures for years up till 1920. Of course, latterly railway operation in that country has been so subject to vicissitudes that even were they available, statistics would be of little value, though they would certainly arouse a considerable degree of interest. We believe it still remains to be seen whether returns of this kind will be compiled and published under the new "order" of things, or whether they will be abandoned as part of the British system to be eradicated. If, as has been held here, such publication tends to diminish the number of accidents, it would seem that the need for reports has been more urgent latterly in Ireland than formerly was the case.

As regards Great Britain the position on the whole is improved. We do not lay great stress upon the figures for each year, as the actual number of fatalities is largely fortuitous, and one serious accident may outweigh the effects of a number in another year. However, the indications are satisfactory. For instance, as regards accidents to trains, in 1922 only 5 persons were killed and 406 injured compared with 18 killed and 589 injured in the previous year. The figures given for 1922 correspond with traffic represented by 1,194,700,000 passenger journeys so that the risk is not great, while if we take the total casualties in train accidents (*i.e.*, inclusive of employees and other persons) the figures of 21 killed and 519 injured compare with a passenger and freight train mileage of 371,300,000. The number of employees killed and injured in train accidents amounted to 4 and 83 respectively, out of a total number employed of 678,105. Of the train accidents in which loss of life occurred three were due to engine failures and three to collisions. There were 12 collisions in which passenger trains were concerned, this figure being much lower than in recent years in which a maximum of 23 in the year has been reached. On the other hand there were five derailments of passenger trains, which figure has not been recorded since 1915. Again defective condition of stock accounts for five accidents this year. These figures are higher than they should be, and have led Colonel Pringle to remark that there was still some leeway to make up before the high pre-war standard of maintenance was regained.

A feature of many of the recent accident reports is now the expression of opinion by the inspecting officer as to whether in his opinion the accident would have been prevented by automatic train control. At the time of the publication of the report of the committee which considered this question, the matter was discussed in these columns. In the present report it is stated that 7 train accidents would have been prevented by automatic train control (provided, of course, that such a system was 100 per cent. efficient). After all, this, on the large train mileage recorded for the year, does not prove any very urgent case, and we trust that no encouragement will be given by the official staff of the Ministry to the recrudescence of the type of sentimentalism from which we suffered here before the war. All accidents are to be deplored, but they should be viewed with some sense of proportion and the public should be educated to realise the fact that, as our modern ways of life go, railway travel is safe, instead of being incited to regard it as unnecessarily dangerous. How many accidents occurred for instance on our railways on Monday last, or over the week end, for which train working was responsible? Compare with this record the list of deaths from accidents on the roads, or even on the sea shore. The fact is that modern life makes more risk inevitable now, and unless some artificial stimulus is given to a scare we readily accept a certain amount of it. We may not all take our life in our hands on motor bicycles and "combinations," but we do not hesitate to travel by the larger car, or entrust ourselves to the care of others in motor omnibuses, flying machines and trains. Unless we are content to live in a twentieth century back water we cannot well do otherwise. There is no reason so far as we can see why the public should be taught to expect a 100 per cent. safety in railway travel any more than in other directions, and if it were attainable in all, what would become of the excitement of the possibility of winning a prize in the daily newspaper insurance schemes?

Compare the fatalities due to train operation with the accidents which automatic train control could not effect, and it will be seen that undue weight is given to the seriousness of the former. For instance, 24 persons were killed and 40 injured by falling out of carriages while in motion, but in this case Colonel Pringle remarks that these represent roughly only one case per 20,000,000 passenger journeys, and they include cases of persons seated on open carriage windows, misconduct such as drunkenness, evasion of ticket collection and so on, and it is not thought that the figure justifies pressure being brought to bear on the companies to adopt elaborate door-locking systems. Here the view taken is relative, as of course it should be with train accidents proper. Further, 16 passengers were killed and 778 injured while alighting from or entering trains. Clearly even a small increase in caution would obviate many of these, but the public insists on taking the risk and resents any restriction of its liberty in such matters. Let us keep things on the same level, and if these little risks are deliberately courted and go to make modern life complete, why should we be asked to insist on making train journeys monotonously uninteresting.

TRADE WITH SOUTH AFRICA.—The half-yearly report, to June, 1923, recently issued by the British Manufacturers' Representatives' Association of South Africa (Incorporated), Cape Town, contains the following paragraph: "As information is to hand that at least one leading firm of London shippers is regularly supplying goods to an auctioneer in this country for disposal, home trade journals who receive a copy of this report may consider it desirable to draw attention to the damaging effect of such shipments on the business of regular importers."

PERSONAL.—We regret to have to record that Dr. Percy Longmuir, the director of research to the British Cast-Iron Research Association, has had to resign his post owing to a serious breakdown in health. Dr. Longmuir has now gone away to the East Coast for a rest, but will continue in office until next November. The council are taking steps to appoint at once a successor to Dr. Longmuir so that the research work now being carried out can be continued without a break. Before Dr. Longmuir finally retires he proposes to issue the bulletins detailing the research work he has carried out.

LITERATURE.

A Dictionary of Applied Physics. Edited by Sir RICHARD GLAZEBROOK, K.C.B., D.Sc., F.R.S. In five volumes. Vol. V. *Aeronautics—Metallurgy.* London: Macmillan and Co., Limited, 1923. [Price 63*s.* per volume.]

THE last of the five volumes of the Dictionary of Applied Physics has appeared, and the completed work demonstrates both the magnitude of the task undertaken and its successful accomplishment. It is a grateful duty to offer congratulations to Sir Richard Glazebrook, who has arranged the scheme, selected the authors, and edited the articles, whose collection will furnish for all time a picture of the condition of applied physics in the first quarter of the twentieth century. We have been reminded in the course of publication, that the work breaks new ground and fills a long-felt gap in scientific literature, for apart from monographs to be found in encyclopædias, no adequate comprehensive summary of the results of physical inquiry and its application to industry, exists. The engineer, the technologist, the science worker, have had to grope their way in ignorance of the results of previous experiment, or to collect their information from original and scattered sources, neither easy of access, nor in the most convenient form for application.

It is possible to see in its appearance another significance. It may be a consequence of the more general recognition of the ability of science and original research to extend industry and promote commerce. The importance of theoretical inquiry has been undervalued, while the evidences of material progress flattered the nation and spelt prosperity to the manufacturer. Research has been too frequently understood as a means of increasing profits and improving existing methods. The editor has so far yielded to the popular estimate that he has endeavoured as far as possible to separate the part played by theoretical inquiry from that of practical application, but each successive volume shows how intimately the two are connected, and that scientific research alone opens a pathway to successful advance. Whether the "Dictionary" furnishes a stimulus to fresh inquiry, or supplies information concerning the achievements of the past, it indicates that the partnership between suggestion and construction, between physics and engineering, is permanent and effective.

It is fitting, too, that while expressing our gratitude to the editor, whose supervision over all has been constant, we should recognise the special services of those who have made the work possible and ensured its success. Many of those whose names are familiar as leaders in scientific research have paused in their own work of furthering knowledge, to tell others of the facts that have been acquired and the use that has been made of them, either as stepping stones in the laboratory to promote advance, or as direct application in the workshop. This duty is the more imperative, as it is impossible to mention all who have given freely of their best, still less to do justice within moderate limits, to the wealth of detail, the admirable arrangement, the thorough insight and masterly handling, that characterize the several contributions.

Only two main subjects—Aeronautics and Metallurgy—come under consideration in this volume, but the comparative novelty of the one and the economic importance of the other, make the contents most interesting. Among the more conspicuous contributors to the first section is Professor Bairstow, who sketches the history of mechanical flight and shows how the invention of the light petrol motor wrought a revolutionary change in the methods by which the solution of the problem had been sought. He discusses with some care the principles underlying the prediction of performance, or the probable speed of horizontal travel and the climbing capacity attained in actual practice, on the finished model. It is admitted that wide discrepancies manifest themselves between the calculated performance and that actually developed. This need occasion no surprise, but Dr. Bairstow holds out the hope that closer agreement will be attained in the near future, since the construction of a new wind channel of larger section at the National Physical Laboratory will permit experimental work to be carried out with a greater degree of refinement.

In a following article, the same author describes the conditions that make for stability in aircraft, the factor that exercises the preponderating influence in reducing the risk of accident. Here, again, it may be inferred that the problem that mathematics solves by means of the theory of small oscillations of a rigid body about a state of steady motion is not precisely that which comes before the flying expert, and that recourse must be had to the lessons derived from actual experiment, which may assume one of two forms: Either long trial on actual service, or the safer and less expensive methods of laboratory and tunnel testing on small and accurately measured models. Various experts deal with the different aspects of the main problem. Mr. Ronald Wood discusses the general question of aerodynamic research in full-sized models, Messrs. R. Jones and Pannell have described experiments on airships, and Mr. Ernest Relf, in collaboration with Mr. H. B. Irving, deals with the other side, Model Experiments in Aeronautics.

Another class of writers treats of the various parts of the completed machine, and necessarily these articles lean towards the engineering and technical rather than to the physical side. Such are the contributions of Dr. Guy Barr on the materials used for the wings of aeroplanes, and the methods of doping; that of Mr. J. W. Dyer on "Airship Fabrics," in which are detailed the broad results of experimental work carried on during the war, as reported in confidential papers; and the description of "Air-Cooled Engines" by the late Mr. G. H. Norman. Articles of another character deal with the means of effecting the lift of airships, the production of helium and the derivation and testing of hydrogen. A mere catalogue of names and titles is, however, of very small assistance in indicating the ground covered or the method of treatment. There are no less than 16 contributors, many of whom write on more than one topic, and therefore any adequate description is impossible. But remembering that each is possessed of first-hand practical knowledge, the collection forms a storehouse of information that will prove of profound assistance both to the student and the expert,

The second part of the Dictionary, that devoted to Metallurgy, stands on rather a different ground from the preceding. Aeronautics cannot yet boast an extensive technical literature, and the articles collected are necessarily characterised by a great amount of originality, the authors themselves in many instances being the investigators, who have made the science possible. In metallurgy, an older science, many excellent treatises and monographs are extant, which deal at length and from various points of view with the subjects whose treatment here is necessarily compressed. The main subjects considered in this section are three: Alloys; Furnaces and Refractories; and the examination and behaviour of metals under special circumstances. Some of the processes, successfully applied to the treatment of special metals, which might have been introduced profitably into the general subject of metallurgy, are probably considered to be more closely allied to chemistry than to physics, and have been excluded on that ground. But though we miss some well-known names whose researches have enriched the science and improved technical methods, we can hardly cavil with the selection or detect undue bias in certain directions.

All must be delighted to hear once again from the veteran, Sir Robert Hadfield, the story of the experiments he made on alloy steels, as far back as 1882, that led to the production of manganese steel described by eminent authorities as a "discovery equal in importance to that of the effect of quenching carbon steel, and the only one of the same order which it had been reserved for our age to make." We welcome the *obiter dicta* and wish there had been more of them. The wider subject of "Special Steels" is treated at considerable length by Mr. W. H. Hatfield. Another welcome contributor is M. C. E. Guillaume, who, attacking the problem of alloys from a different point of view, has given industry the useful combinations of invar and elinvar. An alloy possessing an invariable modulus of elasticity does not seem to be of the same practical importance as one that exhibits no thermal expansibility, at least the applications are not so well known. M. Guillaume rightly calls attention to the value of the latter in geodesy, where the use of the Jaderin tape has proved of such material advantage, and in the compensation of clock pendulums. Elinvar has been used with success in the spiral springs of watches and chronometers, but the public are hardly aware of the introduction, though we are told that more than 50,000,000 of watches are furnished with a compensating spiral. Since 1920, it appears that a further improvement has been made by constructing the spiral of an alloy for which at ordinary temperatures the value of Young's modulus is stationary in the neighbourhood of the maximum ordinate of the curve. Other writers on alloys are Dr. J. Haughton, who writes on the general theory of alloy systems: Dr. W. Rosenhain, who, besides contributing several articles on particular alloys, supplies valuable information on the behaviour of metals under varying conditions of strain and temperature; and Dr. H. Hanson, the author of two papers on "Iron-Carbon Alloys," and on the "Defects and Failures of Metals."

The properties and behaviour of refractories generally are ably described by Mr. E. A. Coad-Pryor, who has contrived to condense much of the information scattered through many journals, English and foreign, within a comparatively short space. The same author has an interesting article on the types of furnace suitable for, and used in, laboratories, where the sources of available energy are liable to be limited in efficiency. Mr. F. A. Fitzgerald, treating of the industrial employment of electric furnaces generally, demonstrates that though this source of heat energy has been long confined, and thought to be only applicable, to the attainment of the highest temperatures, it may now, in the presence of price of coal and labour, be found to provide an economical source of heat where moderate temperatures are required.

In the third possible division of this main section may be placed the papers by Mr. W. D. Haigh, on the "Aggregation and Flow of Solids"; Mr. D. Finlayson's description of the preparation of aluminium, involving the application of electrolysis. The remarks on alloys of aluminium, not the least interesting part of the article, could be more conveniently referred to the first sub-division. A further application of electrolytic methods is seen in the preparation of high conductivity copper for electrical purposes, described by Mr. H. E. Dolphin. Only considerations of space prevent us dwelling on many salient and novel points that the several authors have considered. Where so much is said and so admirably said, it is only possible to express that sense of gratitude to all which we have endeavoured to express to the editor, whom finally we congratulate on the completion of his task.

Tool Engineering, Fixtures for Turning, Boring and Grinding. By Albert A. Dowd and Frank W. Curtis. London: McGraw-Hill Publishing Company, Limited. [Price 17*s.* 6*d.* net.]

This is a very valuable work on the subject of holding articles to be tooled on the rotary types of machines. It does not assume much knowledge on the part of the reader, but is elementary in its method of treatment. The numerous illustrations, line drawings only, and perfectly clear, include all the typical cases that can arise. The drawings number 216, but most of these are groups that embrace several distinct but related forms. The subject is treated on the basis of first principles, and the essentials that underlie practice, instead of that of sets-up of tools for selected pieces of work—a method which has been rather overdone in books of this class. Only a few examples of this kind are given. But all the leading principles that control the designs of fixtures, the forms of the tools used, the factors which control the methods of holding and tooling, and the modifications to which they are subject when affected by the designs of machines employed are very fully illustrated, and critically discussed.

The book contains 16 chapters. The types of chucks used in turret lathes are illustrated with sectional views, and the varied forms of their jaws, with critical observations on the special utilities of each. A good deal of attention is given to the loose jaws. Some of these are special forms, but the principles of their design are applicable to pieces of other shapes. The tool designer does now, in the widest sense, magnify his office. Any shapes may be chucked securely and without distortion, provided the necessary precautions are observed. A great number of fixtures for turret work are illustrated for articles of circular and symmetrical shapes, and for those of irregular outlines. The points in their favour are emphasised, and also the risks that are eliminated by their designs. Four chapters are thus occupied, supplemented by one on inside holding methods, mainly by the use of expanding arbours. The illustrations include parallel and tapered forms, solid and expanding, threaded and equalising, quick-acting and air operated. Another chapter treats very fully of the tools used, for turning, the methods of mounting and adjusting them, of steadies and pilots.

In the chapter on boring tools, most of the common methods of fastening and adjusting cutters are shown along with many that are novel. The causes that result in inaccurate holes are discussed, with the means of their prevention. Facing tools occupy a chapter. The difficulties of producing accurate results with recessing tools are stated, and the fact is emphasised that it may be desirable in some cases to modify an office design for this reason, a measure which applies to other details of turret work and to machining problems generally. This is one of the most informing chapters in the volume. The cutting point of the tool itself is seen to become a secondary matter by comparison with the mechanism by which it is operated. This may include cams, rocking levers, dovetails, slides, rack and pinion, and the use of springs, which elements contribute in some instances to the building up of an ingenious and highly elaborated piece of mechanism, by which accuracy both in respect of diameter, and of longitudinal position, is secured. Also of longitudinal travel of the tool in the case of a wide recess, and of the correct location of two or more recesses in a single bore, and the use of pilots for long bars with much overhang.

A chapter on reamers and floating holders gives a good *résumé* of the subject, with a selection from the numerous inserted blade designs, and with diagrams of the floating holders, with critical observations on the faults of some, and the advantages conferred by others. The chapter on cross-slide tools is illustrated with excellent drawings, and teems with valuable instructions respecting the shapes, and mountings of the tools employed, including the forming group. The subject of attachments covers those for taper turning, and boring, and for producing curved and irregular outlines under the control of forms that actuate the tool slides. The methods by which work is laid out are described, by using tracing paper, under which is placed a scaled drawing of the turret, the spindle and the cross-slide in their respective positions with their leading dimensions. This avoids waste of time in going to the machine to take its capacities, and of the fouling of turret tools with the work, or the cross-slide. Some typical examples of lays-out are given. The work done on vertical machines and boring mills occupies two chapters. Fixtures for grinding complete a work written in a lucid style, by men who are specialists, and illustrated with drawings in a uniform style, and perfect delineation.

Telephony. An Elementary Exposition of the Telephone System of the British Post Office. By T. E. Herbert, M.I.E.E. Illustrated. London: Sir Isaac Pitman and Sons. 1923. [Price 18*s.* net.]

The feature that distinguishes this treatise from so many of the same class is the closeness with which it follows the methods and practice that have been adopted at the Post Office. Whether the practice is best suited to modern requirements, or is that which would be adopted if entire re-arrangement were possible, is outside the question. The object is to supply information concerning the practical working of details that have resulted from the system of accommodation to the growth of demands, and the policy of pursuing the path of least resistance. Since a large number of employees have to be trained to follow the traditions and to continue the working of the system upon the lines upon which it has been developed, it is well that one of the engineering staff, accustomed to the details, should undertake to initiate those who are desirous of entering the service into the operations, and to make them acquainted

with the principles that govern the routine. The author is mainly addressing those who, before undertaking practical work have to submit to preliminary examinations, and has arranged his treatise so as to cover the ground required for the City and Guilds Examination in Grade I, and will probably provide the information demanded from those in the Final Grade, if small demand is made on their mathematical equipment.

In the earlier chapters is presented the ordinary description of instruments with remarks on the construction of Leclanche and of dry cells, the uses of galvanometers, voltmeters and other forms of ordinary apparatus, which it is the purpose of so many books to supply and so many laboratories to provide. With the construction of the Wheatstone bridge and the "Bridge Megger" the student begins to specialise in the forms of instrument selected by the Post Office authorities. But no exclusive preference is given to these, and the student has ample opportunity for contrasting these types with other varieties on the market, whose advantages are fairly pointed out from a practical point of view.

A chapter or section is devoted to sound, and the mechanism of speech transmission, explaining the transformation of the energy of aerial vibrations into corresponding varying electric current energy, but Fourier's theorem is inadequately treated, an inevitable consequence of resolutely refusing the assistance of mathematical analysis. Of such practical matters as the construction of receivers and transmitters, quite sufficient descriptions are given, and from this point forward the author shows clearly how results have been attained from mechanism that has been gradually improved and adopted, evidently enjoying himself amidst the mass of apparatus which he handles so deftly. The student is put into clear possession of the effect which it is desired to produce, and the circuit arrangements or the mechanical adjustments are demonstrated by which that particular result can be secured. Endless experiments have been made to secure efficiency and certainty in operating, but it is the final stage the student is invited to consider. The work has to be done methodically and uniformly, and whether the problem is to detect a leak or to erect a distributing pole, minute and authoritative information is provided whose details may be neither varied nor overlooked.

Historically, the author traces the gradual development of the process of telephony from the magneto system in which a form of generator is required at the subscriber's station, through the common battery signalling system, in which automatic signalling between the subscriber and the exchange is secured, to the common battery system, in which further simplification and more constant conditions are secured by locating at the exchange one large common battery, with adequate current and negligible internal resistance, available for both speaking and signalling. Such a plan dispenses with the subscribers' speaking batteries, effecting thereby considerable saving in maintenance charges. Improvement is not confined only to the economic side, for there is much less variation in the speaking efficiency, owing to the maintenance of a more constant voltage. A secondary cell battery at the exchange will rarely vary 5 per cent. in its voltage, but a subscriber's two-cell speaking battery will vary from 3 volts to 2 volts, causing a corresponding drop in the volume of transmitted speech.

A vast amount of detail has to be erected to secure the necessary efficiency and to give the necessary simplicity in manipulating. By the aid of many well-arranged diagrams, Mr. Herbert succeeds in showing how the requirements are ensured and the method of operating the mechanism. But perhaps we may be pardoned, if we protest against the practice of describing technical arrangements or apparatus by initial letters. To the initiated, doubtless these letters speak as plainly as the printed page, but to those less familiar, the trouble of translation adds to the difficulty of following an argument or an explanation. The difficulty is increased in some cases, when the letters are capable of carrying a double significance. For example, on first meeting the cabbalistic symbol D.P., it meant "Double Pole," later these same letters signify "Distributing Pole." Such a sentence as the following is hard to follow: "In No. 10 C.B Exchanges, the M.D.F. and I.D.F. are combined in one structure, the I.D.F. being arranged above the M.D.F. The I.D.F. in C.B.S. multiple exchanges is fitted *en suite* with the switchboard." Troublesome to novices, no doubt, but the book is intended for those who are treading a particular road to a final goal.

BOOKS RECEIVED.

United States Bureau of Mines. Bulletin No. 213. *Talc and Soapstone, their Mining, Milling, Products and Uses.* By RAYMOND B. LADOO. [Price 25 cents.] Technical Paper No. 314. *Metal Mine Fires.* By D. HARRINGTON and others. [Price 10 cents.] No. 329. *Quarry Accidents in the United States during the Calendar Year* 1921. By WM. W. ADAMS. [Price 10 cents.] Washington: Government Printing Office.

United States Geological Survey. Bulletin No. 686. *Structure and Oil and Gas Resources of the Osage Reservation, Oklahoma.* By DAVID WHITE and others. No. 736—H. *Stratigraphy of the El Dorado Oil Field, Arkansas, as Determined by Drill Cutting.* By JAMES GILLULY and K. C. HEALD. Washington: Government Printing Office.

Refractories for Furnaces, Crucibles, &c. By ALFRED B. SEARLE. London: Sir Isaac Pitman and Sons, Limited. [Price 5*s.* net.]

Theorie der Durchströmturbine. By ENWIN SONNEK. Berlin: Julius Springer. [Price 1*s.* 4*d.*]

Tabellun und Diagramme für Wasserdampf. Berechnet aus der Spezifischen Wärme. By Dr. OSC KNOBLAUCH. Munich and Berlin: R. Oldenbourg. [Price 1*s.* 9*d.*]

Ur Professor Johan Erik Cederblome Efterlamnade Papper Afhandlingar och Experiment Rörande Flygproblemets Lösning. Uppsala: Almqvist and Wiksells Boktra A.B. [Price 15 kr.]

The Structure of the Atom. By E. N. da C. ANDRADE, D.Sc., Ph.D. London: G. Bell and Sons, Limited. [Price 16*s.* net.]

Smithsonian Institution. United States National Museum. Bulletin No. 102. Part 8. *The Mineral Industries of the United States. Manufactured Gas in the Home.* By SAMUEL S. WYER. Washington: Government Printing Office. [Price 10 cents.]

United States Bureau of Standards. Scientific Papers No. 468. *Formulas and Tables for the Calculation of the Inductance of Coils of Polygonal Form.* By FREDK. W. GROVER. [Price 10 cents.] No. 471. *Methods of Measurement of Properties of Electrical Insulating Materials.* By J. H. DELLINGER and J. L. PRESTON. [Price 15 cents.] Washington: Government Printing Office.

United States Bureau of Labour Statistics. Bulletin No. 325. *Union Scale of Wages and Hours of Labour, May* 15, 1922. [Price 20 cents.] No. 327. *Wages and Hours of Labour in Woollen and Worsted Goods Manufacturing,* 1922. [Price 10 cents.] No. 329. *Wages and Hours of Labour in the Men's Clothing Industry,* 1911 *to* 1922. [Price 5 cents.] Washington: Government PrintingOffice.

Die Gesetze zum Schutze des Gewerblichen Ergentums. Compiled by Dr. ERWIN HUTTNER. Second edition. Reichauberg: Gebrüder Stiepel Gesellschaft.

Screw Cutting Simply Explained. By GEORGE GENTRY. London: Percival Marshall and Co. [Price 9*d.* net.]

Gear Wheels Simply Explained. By ALFRED W. MARSHALL, M.I.Mech.E. London: Percival Marshall and Co. [Price 9*d.* net.]

Clock Repairing and Adjusting. By W. L. RANDELL, London: Percival Marshall and Co. [Price 9*d.* net.]

Mechanical Engineering Formulæ. By E. W. HUDDY. New York: Spon and Chamberlain. London: E. and F. N. Spon. [Price 4*s.* 6*d.* net.]

Locomotive Catechism. A Practical and Complete Work on the Design, Construction, Running and Repair of all kinds of Locomotives, for Firemen, Engineers, Trainmen, &c. By ROBERT GRIMSHAW, M.E. Thirteenth edition revised. New York: The Norman W. Henley Publishing Company. [Price 4 dols.]

THE COMMER PARAFFIN CARBURETTOR.

THE relative cheapness of paraffin or kerosene, as compared with petrol, has induced many designers to attempt the use of the heavier liquid as fuel for motor cars and commercial vehicles. Numerous paraffin carburettors have been devised, mostly on the principle of passing the vapour or spray from the liquid through tubes heated by the exhaust gases from the engine. In addition to the difficulties of starting, it has not been easy to vapourise the paraffin sufficiently well in this way to ensure complete combustion in the cylinder, with the result that a heavy carbon deposit was liable to occur and the exhaust tended to be smoky and evil-smelling. A further result of incomplete vapourisation was the tendency of liquid paraffin to pass the piston rings and get down into the crank-case, rendering the oil unfit for lubrication. These drawbacks have prevented any appreciable progress in the application of paraffin as fuel for road vehicles up to the present, but there is no reason to consider them insuperable, and the saving in running costs which paraffin would bring about has resulted in constant efforts to circumvent them. Messrs. Commercial Cars, Limited, of Luton, Bedfordshire, have been experimenting for many years with the utilisation of paraffin fuel, and have now perfected a design of carburettor which, in the light of their long experience of the exigencies of road transport, is considered to afford a complete and satisfactory solution of the problem.

The Commer paraffin carburettor, which is illustrated in Figs. 1 to 4, on page 186, is of much smaller dimensions than the generality of such apparatus. It works on the principle of vapourising the paraffin by direct contact with very hot gas or air instead of transmitting the heat through metal walls or tubes in accordance with the usual practice in these devices. The carburettor is self-contained and does not require special exhaust or induction pipes or other fittings, nor has any alteration to be made to the engine. Referring to Figs. 2 to 4, the paraffin supply is connected to the union A and is controlled by an ordinary carburettor float, as shown in Fig. 4. From the float chamber it travels into a passage B in the body of the main casting, to which are connected the main jet C and the auxiliary jet D. The main jet terminates just above the level at which the float valve maintains the oil, but the latter rises through the auxiliary jet into the bottom of a chamber E. Fitting into the sides of this chamber is a casting F, the bottom of which is pierced with a number of holes, each of which is filled by an asbestos wick G. The lower ends of these wicks dip into the paraffin in the chamber E.

To start the engine from the dead cold condition, the cover H is removed, by loosening the wing-nut which holds it, so that air has free access to the inside of the casting F. A high-tension spark is then passed from the sparking plug to a piece of metal surrounding the wick directly beneath the plug. This ignites the wicks, which are allowed to burn for a minute or so, to warm the casting. The cover H is then replaced and the engine is ready to be started. The spark is again switched on and the engine cranked round. The operation of cranking draws air through a small plate, which is perforated with holes as shown in the photograph. This air is separated into two portions. One passes directly into the interior of the cover H, down through the curved pipe and upwards past the end of the main jet C. This is the main vapourising air which draws the paraffin out of the jet and carries it upwards in the form of mixed vapour and spray. The other portion of the air is led to an annular space L surrounding the casting F, and passes into the interior of the casting through the numerous small holes drilled through its walls. The presence of this air keeps the wicks burning after they have been relighted by the spark. A small part of the heated products of combustion pass upwards into the cover H, and mix with the pure incoming air to raise its temperature. The major part, however, pass out through the passage M at a very high temperature, and being deflected by the casting N, meet the paraffin spray as it emerges from the jet and complete its vapourisation.

The baffle above the jet assists the mixture and forces the vapour into contact with the walls of the casting N which are maintained at a high temperature by the hot gas or flame surrounding them. The mixture eventually passes away through three ports in the dome-like cap and thence to the throttle-valve. This is shown in position in Fig. 1, but we do not otherwise illustrate it. The mixture, and the additional air required for combustion, are controlled by separate butterfly valves, so connected that a richer mixture is automatically provided when the engine is "idling," and the mixture strength may also be increased above the normal under overload conditions. The same principle might, of course, be equally applied to the throttle of a petrol carburettor. It will have been gathered from the description of the apparatus that the engine can be started within a minute or so from cold, without the use of petrol or any means of auxiliary heating. As soon as the engine is firing, the spark in the vapouriser is switched off, as the passage of air over the wicks is sufficient to keep them alight. Should they be blown out by a backfire, or become extinguished from any other cause, they can be instantly re-ignited by switching on the spark momentarily. After the engine has been running long enough to heat the water in the radiator appreciably, it may be stopped and re-started after an interval amounting to as much as a couple of hours, without removing the cover of the carburettor.

So far as economy of fuel is concerned, quite apart from the cheapness of paraffin as compared with petrol, some very interesting figures have been furnished us by Messrs. Commercial Cars, Limited, which we reproduce in the table on page 186. They serve to show that the amount of paraffin which is burnt in the carburettor in order to maintain the vapourisation is negligible compared with that which is effectively used in the development of power. The power developed by a standard petrol engine when running on paraffin very closely approaches that developed by the same engine when running on its normal fuel, as will be evident from the test results. When developing maximum power the economy in fuel, when paraffin is used, is

THE COMMER PARAFFIN CARBURETTOR.

CONSTRUCTED BY COMMERCIAL CARS, LIMITED, ENGINEERS, LUTON.

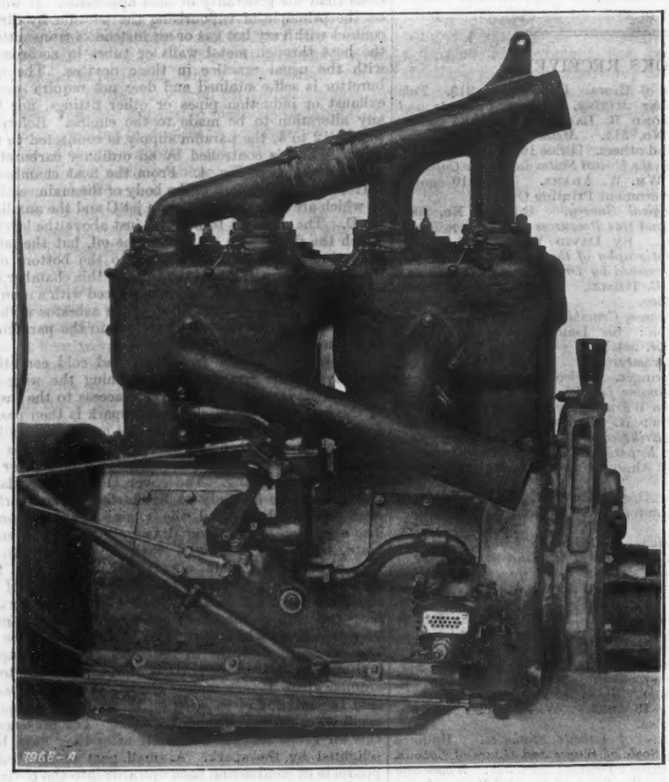


Fig. 1.

Fig. 2.

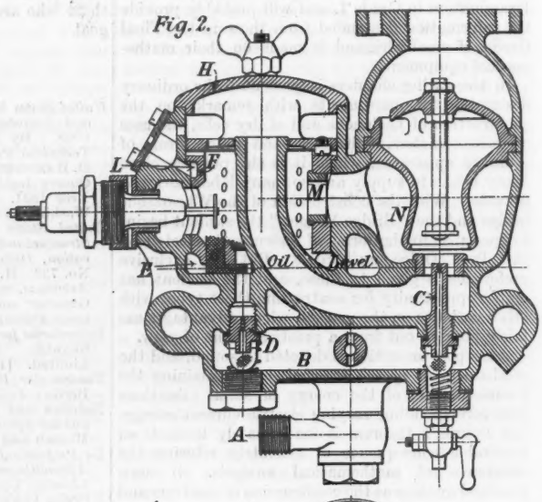
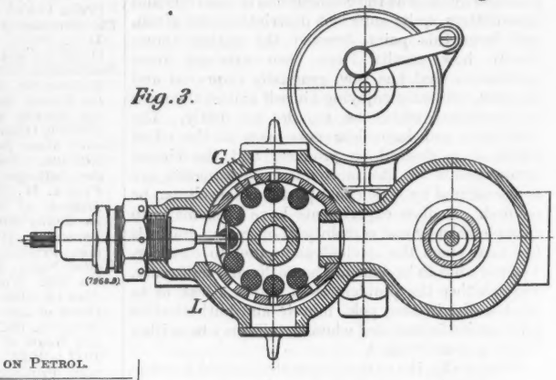


Fig. 3.



Comparative Test Sheet of Paraffin Carburettor and "Claudel Carburettor" on Petrol.

Four-Cylinder Engine "Commer." 100 mm. Diameter Bore. 120 mm. Stroke.

Throttle Fully Open.

Revs. per Minute.	Brake Horse-Power.		Consumption. Pints per Horse-Power Hour.	
	Paraffin Carburettor.	Claudel Carburettor.	Paraffin Carburettor.	Claudel Carburettor.
600	14·08	13·6	0·621	0·862
800	19·2	18·9	0·633	0·840
1,000	23·42	23·7	0·668	0·775
1,200	28·4	27·2	0·653	0·748
	If average power on petrol is taken as 100 per cent. comparative figure on paraffin becomes 102 per cent.		If average consumption on petrol is taken as 100 per cent. comparative figure on paraffin becomes 79·7 per cent.	

Throttled Positions.

1,000	9·2	8·1	0·862	1·37
1,000	12·33	11·6	0·742	1·28
1,000	16·66	16·66	0·693	0·856
			If average consumption on petrol is taken as 100 per cent. comparative figure on paraffin becomes 65·6 per cent.	

Four-Cylinder Engine "Commer." 110 mm. Diameter Bore. 140 mm. Stroke.

Throttle Fully Open.

Revs. per Minute.	Brake Horse-Power.		Consumption. Pints per Horse-Power Hour.	
	Paraffin Carburettor.	Claudel Carburettor.	Paraffin Carburettor.	Claudel Carburettor.
600	18·6	19·9	0·654	0·810
800	25·47	26·0	0·668	0·809
900	28·8	29·1	0·668	0·788
1,000	29·5	30·8	0·739	0·807
1,200	35·2	34·6	0·736	0·776
	If average power on petrol is taken as 100 per cent. comparative figure on paraffin becomes 98 per cent.		If average consumption on petrol is taken as 100 per cent. comparative figure on paraffin becomes 86·8 per cent.	

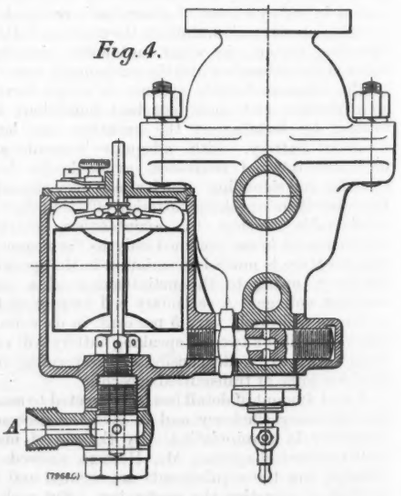
Throttled Positions.

1,000	6·66	6·66	1·28	1·778
1,000	15·16	15·17	0·842	1·152
1,000	19·66	20·0	0·750	0·987
	Tests carried out by Commercial Cars, Ltd., Biscot-road, Luton.		If average consumption on petrol is taken as 100 per cent. comparative figure on paraffin becomes 73·3 per cent.	

about 16 per cent. while with the engine throttled the saving in fuel per brake horse-power is nearly double this figure. These figures are confirmed by numerous road tests carried out on a 3-ton Commer lorry, with a gross loaded weight of 7·5 tons, to which a paraffin carburettor has been fitted. We have had an opportunity of noting the performance of this vehicle, which with a load of 3½ tons aboard, exclusive of four men and sundry tools, &c., had no difficulty in climbing a test hill with an average gradient of 1 in 7, and about a quarter of a mile long. During a run of about 20 miles over ordinary give-and-take roads its behaviour at all speeds was indistinguishable from that of a petrol vehicle and the exhaust was never visible. An average run of 9½ miles per gallon of paraffin is obtained with this lorry carrying the load mentioned.

A similar carburettor has been supplied to another firm of motor lorry manufacturers, who reported that one of their vehicles driven by their own men, and weighing 8 tons gross, averaged 8·25 miles per gallon of paraffin when working over a very hilly route with frequent stoppages. Paraffin carburettors of the same design are equally suitable for motor car engines, to which they may be applied without varying the compression or altering the engine in any way. We were taken for a run in a car so fitted, and the behaviour of the engine, whether as regards flexibility in traffic, acceleration or smokelessness, was quite indistinguishable from that of an engine running on petrol. This car had run some 1,500 miles with the paraffin carburettor, and no trouble whatever had been experienced from carbon deposits in the cylinders, unconsumed paraffin in the crank-case or any other fault connected directly or indirectly with the fuel used.

Fig. 4.



THE "SISKOL" ELECTRIC COAL-CUTTER.

MESSRS. INTERNATIONAL CHANNELLING MACHINES, LIMITED, SHEFFIELD.

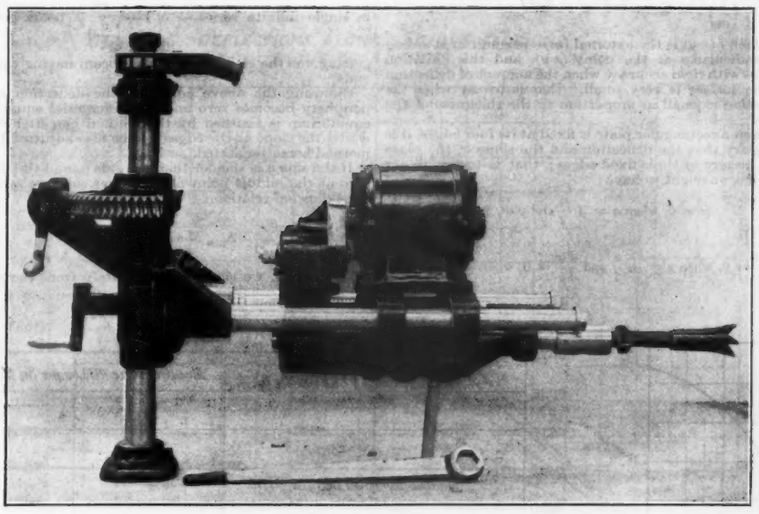
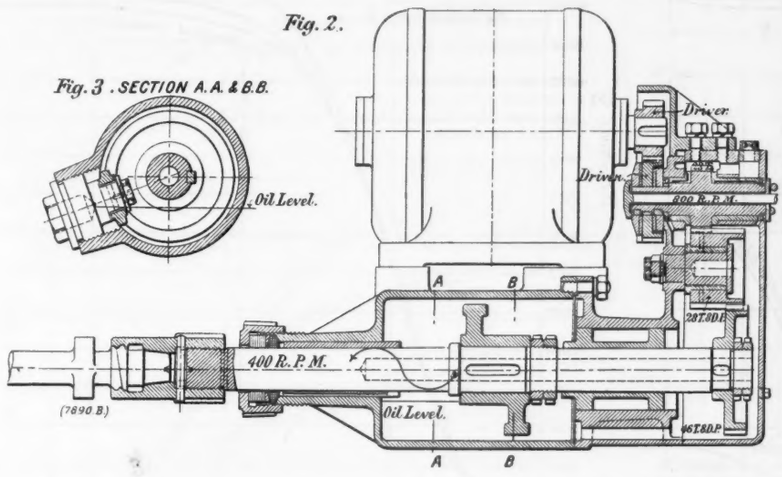


FIG. 1.



THE SISKOL ELECTRIC COAL CUTTER.

AT the recent Mining Exhibition at the Royal Agricultural Hall, Messrs. International Channelling Machines, Limited, of 490, Penistone-road, Sheffield, showed an electrically-driven heading machine, which we illustrate in Figs. 1 to 3 above. The machine consists of an adjustable pillar fixed between the floor and roof of the mine, and carrying a horizontal arm. This arm is adjustable for height on the pillar and may also be rotated through a considerable horizontal angle by means of a worm and quadrant. Mounted on the horizontal arm is an electric motor of 3 h.p., which drives the cutting tool by means of the gear shown in Figs. 2 and 3. The pinion on the motor spindle drives a spur-wheel which is connected by friction plates to a second pinion. The latter drives a broad toothed idle wheel which in turn drives a wheel on the drill spindle, causing the latter to rotate at a speed of 400 r.p.m. The frictional drive of the second shaft protects the motor and gearing should there be any jamming of the tool. All gears are of steel with machine-cut teeth.

On the drill spindle is keyed a curved cam which runs in contact with a fixed roller, shown independently in Fig. 3. The effect of the arrangement is to cause the spindle to have a reciprocating motion as it rotates, the breadth of the teeth on the idle pinion being sufficient to allow for this motion without the gear coming out of mesh. As the machine works, the tool is swung to and fro' across the coal face by means of the worm and quadrant already mentioned. Thus a continuous channel is cut in the coal. Headings or bords up to 20 ft. wide and 5 ft. deep can be cut with one setting of the column. The total weight of the machine is under 7 cwt., it is portable and easy to operate, and a 3-b.h.p. motor is sufficient for the hardest cutting.

THE CHEMIST AND INDUSTRY.—Stellenbosch University, says *The South African Mining and Engineering Journal*, has paid a compliment to Kimberley, to the diamond industry and to De Beers Consolidated Mines, Limited, in asking Sir David Harris to perform the ceremony of opening the new chemical laboratory, the construction and equipment of which have been rendered possible mainly by the munificent gift by De Beers to the university of 25,000*l.*, a condition of which was that it should be applied to the forming of South African chemists.

TICKET ISSUING MACHINES ON THE UNDERGROUND.—To accelerate the booking of passengers during the rush hours, a battery of 12 automatic ticket issuing machines was installed some little time ago at Victoria Station, of the District Railway as an auxiliary to the ordinary booking office facilities, and we understand that these machines are now supplying tickets at the rate of 2,500,000 per annum or about 30 per cent. of the total bookings at the station. Similar installations have been provided at other important stations on the Underground system and others will follow in due course. The rate of issuing tickets from booking offices has also been accelerated by the provision of "Rolltio" and "Automaticket" machines operated by the booking clerks, and tests have shown that these machines each have an output of over 1,000 tickets per hour in spite of the time occupied in giving change.

A PLATINUM "BOOM" IN THE UNITED STATES.

THE main source of the world's supplies of platinum is normally Russia, which once had an output of 300,000 oz. per annum, derived from gravel beds. As a result of the war the price of platinum is about three times what it was formerly, and the temptation has apparently been considerable in the United States to boom platinum mining in that country. To this end, all sorts of properties have been pronounced to be capable of producing platinum from ores of various kinds and even shales and sands. As a matter of fact the country, save in very small quantities, is practically destitute of platinum, as it is of nickel and tin, and the cases in which the United States Bureau of Mines has been able to check claims advanced, have revealed at the most practically unworkable traces of the metal. Platinum was the subject of a good deal of prospecting and assaying on the part of the Bureau during the war, when it was thought that such work might reveal sources of supply which would then have been very valuable. The work, then and since carried out, served for the most part to convince the officials that the platinum resources were, however, very small. At its best the United States have produced less than 1,000 oz. a year, and that as ancillary to the working of gold, silver and copper, without which the platinum recovery would have been uneconomical. The Bureau's investigations have led to the examination of a large number of samples, in most of which no platinum whatever was discovered though rich claims had been made and certified. In one case platinum was found in the form of soluble platinum salts and sponge, "neither of which exists in nature," to quote the damaging judgment of the Bureau; another "sample revealed wire and foil therein."

As it had been claimed that many of the samples did not lend themselves to ordinary assay methods, and most of the promising claims were made in connection with special methods of analysis or assaying, the Bureau instituted a number of tests of a similar character, but with negative results. The fire assay method is held in all cases by the Bureau to be the most effective and reliable. The relatively small quantities which have been recovered in conjunction with work on other metals have mainly been from well-known lode deposits in Wyoming, Nevada, Colorado and Alaska. In all these cases the platinum is present in very small quantities and is only recovered as a by-product, usually in working copper ore. Black sand deposits have been tested but found to contain nothing workable, but the black sand concentrate from dredges and hydraulicing plants has been found to yield recoverable quantities. As the dredges alone handle over 50,000,000 cub. yards of gravel per annum the actual platinum content is infinitesimal and would not be workable alone.

AUTOMOBILES *versus* RAILWAYS.—A Danish railway commission is at present dealing with the problem of using either automobiles or railways in certain districts, more especially in connection with several private railway projects which are at present under consideration. The investigation has been extended to Sweden and Norway, where regular route automobiles are used to a considerable extent. In the Bohuslän district; to mention one example from Sweden, the State substantially subsidises a number of automobile routes. In Norway the State devotes 400,000 kronen annually to the support of such routes, and the postal department a similar sum. In Denmark, such heavy taxes are proposed for route automobiles, with a view to road maintenance, that these taxes are likely to completely jeopardise the traffic, but hopes are entertained that public opinion will react against such heavy charges. The matter will come before the Legislature next session.

THE ORIGIN OF PETROLEUM AND NICKEL.—In a paper recently contributed to the Liverpool Section of the Society of Chemical Industry, Mr. W. Ramsay comments on the presence of traces of nickel in almost all natural oils. It is true, as Ramsay points out, that carbon and its oxygen compounds can, in the presence of catalysts, be hydrated, first into methane and, at higher temperatures and pressures, into higher hydrocarbons; but the equilibria are complex, and more is known about cracking or breaking down oils than about building them up. Yet from experiments carried out by Sabaher, Senderens and others natural oil can be synthetised with the aid of hydrogen and catalysts from acetylene, and it has been suggested that the traces of nickel found first in Mexican petroleum are the residues of the nickel which had helped in the hydrogenation process. Ramsay finds up to 82 parts in 1,000,000 of nickel in Mexican petroleum, 94 parts in some Persian petroleum and next to none in others, and on the whole hardly any nickel in the petroleum from Burmah and the East Indies; further, there are 200 parts and more of nickel in Trinidad asphalt and in American pitch, but none in German ozokerite. The relative richness in nickel seems to go together with a richness of the oil in paraffin constituents. But it is rather awkward for the assumed nickel catalysis that the Mexican oils are also rich in sulphur, which is a catalytic poison, and that nickel is not the only metal occurring in natural oils, though some metals, like copper, are likewise capable of favouring catalysis. Mr. J. E. Hackford discovered iron, copper, lead, nickel, vanadium and gold in the ashes of Mexican oil, and he ascribed their presence to the infiltration of sea water in which the metals had been dissolved. The petroleum originated, in his opinion, from seaweed. So far the hypothesis that petroleum is formed by some hydrogenation of carbon or carbon compounds, in the interior of the Earth, favoured by nickel as a catalyst, rests on a very slender basis.

THE STRESS ON RECTANGULAR PLATES.*

By K. Sezawa, Associate Member.

The effect of stresses on a rectangular plate which is fixed at the periphery and is subjected to an external force acting perpendicularly to its surface, has been studied already by a few students, but so far as the author is aware some have merely attempted to solve the problem by using hypothetical formulæ, whilst others have tried to draw conclusions from the results of unsatisfactory experiments, which could hardly be relied upon to provide an authentic solution of the problem. During the last two years, the author has had an opportunity of studying the subject and has been working out the distribution of stress from his own formula, based on a theoretical principle, whilst at the same time he has been carrying out comparatively reliable experiments, and on comparing his results, he has been gratified to find them tally with quite satisfactory accuracy.

About a month ago, the author came across Mons. Pigeaud's work,† in which he found a mathematical solution of the problem. It is somewhat complicated, but nevertheless is quite an admirable one. Thereupon the author at once took up this method and worked out certain solutions and found the results tallied comparatively well with those obtained by his own mathematical solution and his experiments. This fact gave the author further confidence in his study and work.

I. *Mathematical Solution.* (1) *Author's Method.*—In this solution the following notations are used :—

a, b = breadth and length of the rectangular plate respectively.
t = thickness of the plate.
x, y = co-ordinates of a point referred to the centre lines X, Y, of the plate.
w = deflection of the neutral surface.
E = Young's modulus.
$\frac{1}{m}$ = Poisson's ratio.
p = uniform load
$\sigma_x, \sigma_y, \tau_{xy}$ = normal and tangential stresses parallel to X X, Y Y, and X Y, respectively.
h = distance of a point from the neutral surface.

$$I = \frac{t^3}{12}$$

$$D = \frac{1}{1-\left(\frac{1}{m}\right)^2}\frac{E t^3}{12}$$

Generally speaking, in order that a flat plate of uniform thickness under an external force acting perpendicularly to its surface may be in a state of equilibrium, the following differential equation must hold good, whatever point of the plate is taken into consideration.

$$\frac{1}{12}\frac{E t^3}{1-\left(\frac{1}{m}\right)^2}\left(\frac{\partial^4 w}{\partial x^4}+2\frac{\partial^4 w}{\partial x^2 \partial y^2}+\frac{\partial^4 w}{\partial y^4}\right)=f(x,y)^* \quad . \quad (1)$$

In which $f(x\,y)$ is the external force per unit area acting perpendicularly at the point $(x\,y)$, and this equation applies with rigid accuracy when the amount of deflection of the surface is very small,† that is to say when the deflection is small in proportion to the thickness of the plate.

When a rectangular plate is fixed at its four edges, it is necessary that the deflection and the slope of the plate shall be zero at these fixed edges ; that is to say, in our solution we ought to have :

$$w = 0, \text{ when } x = \pm\frac{a}{2} \text{ and } y = \pm\frac{b}{2}$$

and

$$\frac{dw}{dx} = 0, \text{ when } x = \pm\frac{a}{2} \text{ and } \frac{dw}{dy} = 0, \text{ when } y = \pm\frac{b}{2}$$

Fig. 1. SLOPE ALONG EDGES.

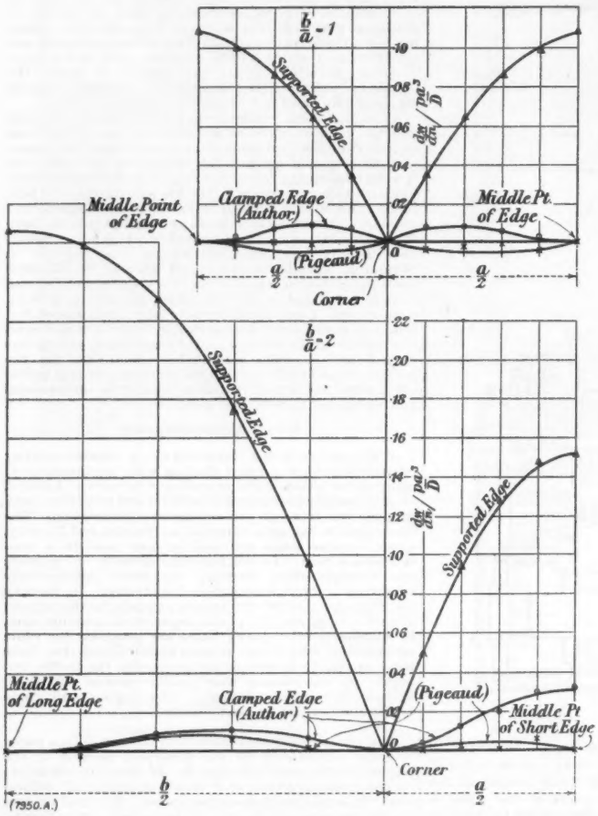
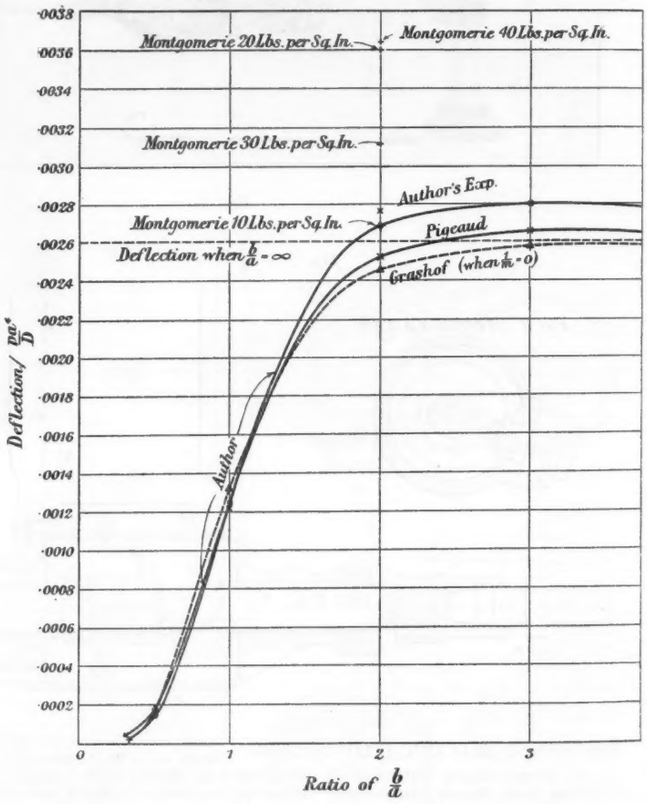


Fig. 2 DEFLECTION AT CENTRE.


Montgomerie 20 Lbs. per Sq. In.
Montgomerie 40 Lbs. per Sq. In.
Montgomerie 30 Lbs. per Sq. In.
Author's Exp.
Montgomerie 10 Lbs. per Sq. In.
Pigeaud
Deflection when b/a = ∞
Grashof (when 1/m = 0)
Deflection / pa⁴/D
Author
Ratio of b/a

Now it is an exceedingly difficult matter to satisfy at the same time all the boundary conditions and the above differential equation, therefore the author has made the following approximations : The solution shall satisfy everywhere the above differential equation so as to keep every part of the plate in equilibrium, and also the deflections at the edges shall be zero ; but the slope along the edges is not everywhere zero, but only accurately zero at the centres of the longer edges. At other points there still remains a very small amount of residual slope.

It is assumed that the deflection w can be represented in the following form :—

$$w = \sum_{m=1}^{\infty}\sum_{n=1}^{\infty} A_{mn}\cos\frac{m\pi x}{a}\cos\frac{n\pi y}{b} + c\left(1-\frac{x^2}{\left(\frac{a}{2}\right)^2}\right)\left(1-\frac{y^2}{\left(\frac{b}{2}\right)^2}\right) \quad . \quad (2)$$

In this case m and n should be odd numbers. A_{mn} and c are constants which are to be determined by the conditions hereafter stated.

It may be noted that the above equation is not chosen at random, for the term in series in the first part on the right-hand side of equation (2) is the correct form for a rectangular plate supported at the edges* and the term not in series in the second part on the right-hand side of the equation is derived from the well-known fact that in the case of a linear beam having a length a, the term in single infinite series $+ c\left(1-\frac{x^2}{\left(\frac{a}{2}\right)^2}\right)$ holds good in getting out the elastic curve for a beam having clamped ends.

By using the above equation, the deflection at the periphery becomes zero and the differential equation of equilibrium is satisfied by the method hereafter stated, whilst the slope at the edges will be also adjusted by the method hereafter stated.

If the side a is smaller than the side b, and the slope is zero at the middle point of the larger side, we arrive at the following relation :

$$\pi \sum_{m=1}^{\infty}\sum_{n=1}^{\infty} A_{mn} M \sin\frac{m\pi}{2} + 4C = 0 \quad . \quad . \quad (3)$$

Using this, we shall find ultimately from the results of calculations that the slopes at the periphery are all small.

Now by continuing equation (2) with equation (1), we have :

$$\frac{\partial^4 w}{\partial x^4} + 2\frac{\partial^4 w}{\partial x^2 \partial y^2} + \frac{\partial^4 w}{\partial y^4} = \sum_{m=1}^{\infty}\sum_{n=1}^{\infty} A_{mn}\left[\left(\frac{m\pi}{a}\right)^2+\left(\frac{n\pi}{b}\right)^2\right]^2 \cos\frac{m\pi x}{a}\cos\frac{n\pi y}{b} + \frac{8C}{\left(\frac{a}{2}\right)^2\left(\frac{b}{2}\right)^2} = \frac{f(x\,y)}{D} \quad . \quad . \quad (4)$$

where

$$D = \frac{1}{12}\frac{E t^3}{\left(1-\frac{1}{m}\right)^2}$$

This relation holds good when $f(x\,y)$ is symmetrical with respect to the centre line of the plate. However, here we will take the simple case that $f(x\,y) = p$, because the constant pressure p may be assumed in all the cases connected with the outside plating of a vessel, and in treating the subject the external force will accordingly

* Paper read at the spring general meeting of the Japanese Society of Naval Architects, 1923.
† Guston Pigeaud, "Résistance des Matériaux et Elasticité," 1920.

* Föppl, "Vorlesungen über Technische Mechanik V," &c.
† John Prescott, "The Equation of Equilibrium of an Elastic Plate under Normal Pressure," *Phil. Mag.*, January, 1922.

* Clebsch, "Théorie de l'Elasticité des Corps Solides de M. de Saint-Venant," 1883.

be always considered as p. The solution of the problem may now be arrived at by determining A_{mn} and C from the equations (3) and (4). However, at present for convenience, considering C as already known from the equation (4), and using the ordinary method of determining the coefficient of Fourier's double series, we will solve for A_{mn}.

From this equation we get A_{mn} in terms of C, and if we substitute the values of A_{mn} thus obtained in the equation (3) we shall have an equation with one variable C, and thence we should be able to obtain the value of C.

Again, by substituting this value of C in the equation (5) the value of A_{mn} would be determined.

Fig. 3. **DEFLECTIONS ALONG VARIOUS SECTIONS (DUE TO AUTHOR).**

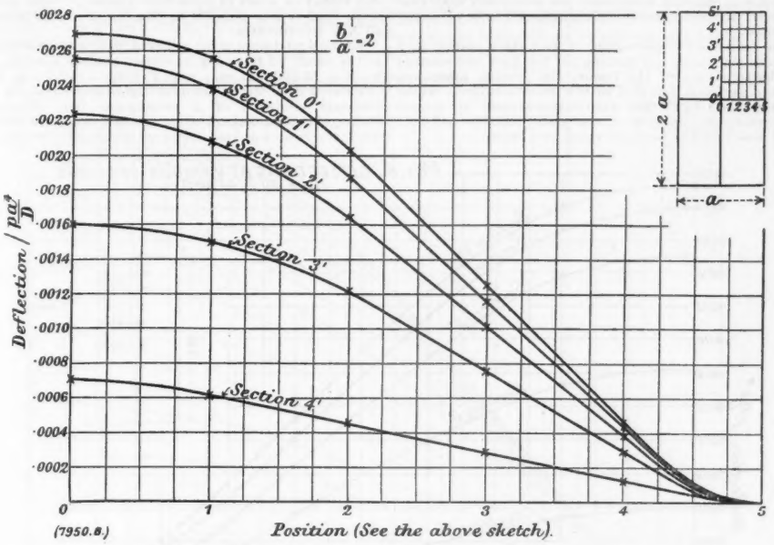


Fig. 4. **STRESSES IN VARIOUS POSITIONS.**

1, 2, 3, 4 - Stress at Centre (Montgomerie)
A ..... (Author's Exp.)
1', 2', 3', 4' ..... on Edge (Montgomerie)
B ..... (Author's Exp.)

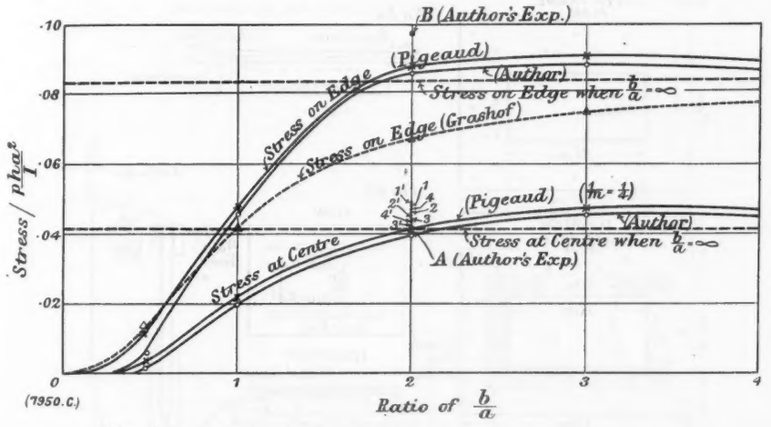
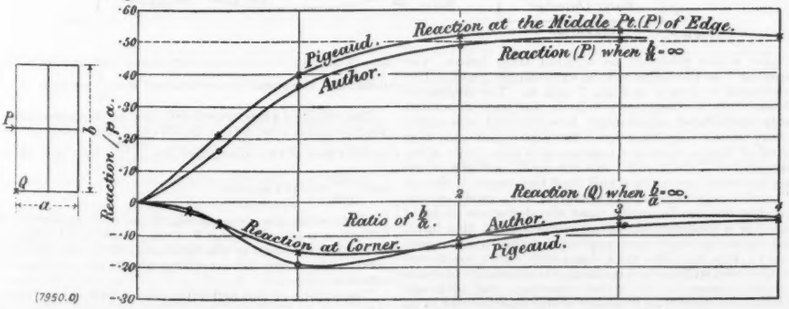


Fig. 5. **REACTION OF SUPPORT.**



We have, in fact:

$$A_{mn}\left[\left(\frac{m}{a}\right)^2+\left(\frac{n}{b}\right)^2\right]^2\pi^6 = \left[\frac{p}{D}-\frac{8C}{\left(\frac{a}{2}\right)^2\left(\frac{b}{2}\right)^2}\right]\frac{16}{mn}\sin\frac{m\pi}{2}\sin\frac{n\pi}{2} \quad (5)$$

As the series converges very quickly the calculations have been taken to the sixth term.

It is important to know to what extent the state of the elastic surface of the plate thus considered approximates to the actual state. Now in referring to Fig. 1 it is clearly seen that what the author calls the "Slope at Clamped edge" is exceedingly small, so that it is almost negligible compared with the case when the plate is merely supported at the edges. Here the cases $\frac{b}{a}=1$ and $\frac{b}{a}=2$ have alone been worked out; still as the ratio of $\frac{b}{a}$ increases, the slope on the smaller side would naturally increase, but ultimately when $\frac{b}{a}$ becomes infinity, it becomes the case of ordinary clamped beam and the error would vanish. Now the central deflection of the plate being one of convenient comparative measures, it has been calculated for various ratios of $\frac{b}{a}$ and is represented in terms of $\frac{p\,a^4}{D}$, the results being shown in Fig. 2.

It will be easily seen from this figure that in the neighbourhood of $\frac{b}{a}=2$ the deflection is almost the same as when $\frac{b}{a}=\infty$, that is to say, almost approaches the case of a linear beam. At the same time, it may look somewhat strange to have the deflection at the neighbourhood of $\frac{b}{a}=2\cdot3$, slightly larger than that at $\frac{b}{a}=\infty$. but such is not uncommon in all our mathematical solutions, and the discrepancy being exceedingly small, may be taken as unavoidable.

The amount of the deflection at various sections may be calculated from equation (2), and as an example the case for $\frac{b}{a}=2$ is shown in Fig. 3.

The normal strain of the plate $h\frac{\partial^2 w}{\partial x^2}$, $h\frac{\partial^2 w}{\partial y^2}$ and the tangential strain $h\frac{\partial^2 w}{d\,x\,d\,y}$ may be written as:

$$\left.\begin{aligned}
h\frac{\partial^2 w}{\partial x^2} &= -h\left[\sum_{m=1}^{\infty}\sum_{n=1}^{\infty}A_{mn}\left(\frac{m\pi}{a}\right)^2\cos\frac{m\pi x}{a}\cos\frac{n\pi y}{b}+\frac{2C}{\left(\frac{a}{2}\right)^2}\left(1-\frac{y^2}{\left(\frac{b}{2}\right)^2}\right)\right]\\
h\frac{\partial^2 w}{\partial y^2} &= -h\left[\sum_{m=1}^{\infty}\sum_{n=1}^{\infty}A_{mn}\left(\frac{m\pi}{b}\right)^2\cos\frac{m\pi a}{a}\cos\frac{n\pi y}{b}+\frac{2C}{\left(\frac{b}{2}\right)^2}\left(1-\frac{x^2}{\left(\frac{a}{2}\right)^2}\right)\right]\\
h\frac{\partial^2 w}{\partial x\partial y} &= h\left[\sum_{m=1}^{\infty}\sum_{n=1}^{\infty}A_{mn}\frac{m\,n\,\pi^2}{a\,b}\sin\frac{m\pi x}{a}\sin\frac{n\pi y}{b}+\frac{4\,C\,x\,y}{\left(\frac{a}{2}\right)\left(\frac{b}{2}\right)}\right]
\end{aligned}\right\} \quad (6)$$

and we may get the normal and tangential stresses parallel to X X, Y Y and X Y by substituting the values of (6) in the following equations:

$$\left.\begin{aligned}
\sigma_{xx} &= -\frac{E\,h}{1-\left(\frac{1}{m}\right)^2}\left(\frac{\partial^2 w}{d\,x^2}+\frac{1}{m}\frac{\partial^2 w}{\partial y^2}\right)\\
\sigma_{yy} &= -\frac{E\,h}{1-\left(\frac{1}{m}\right)^2}\left(\frac{\partial^2 w}{\partial y^2}+\frac{1}{m}\frac{\partial^2 w}{\partial x^2}\right)\\
\tau_{xy} &= -\frac{E\,h}{1+\frac{1}{m}}\frac{\partial^2 w}{\partial x\,\partial y}
\end{aligned}\right\} \quad (7)$$

It is obvious that the limits for the magnitude of stresses on a rectangular plate are at the centre and at the middle point of an edge of the plate; therefore the calculation for the stresses at such points has been made by the author by using the above equations. Although stress is generally a function both of $\frac{b}{a}$ $\frac{p\,h\,a^2}{I}$ and Poisson's ratio $\frac{1}{m}$, it is also obvious that here the stress is independent of $\frac{1}{m}$.

In Fig. 4 the magnitude of the stress is represented for various values of $\frac{b}{a}$. Now Poisson's ratio $\frac{1}{m}$ becomes quite an important factor at the centre of the plate; the results of calculations taking $\frac{1}{m}=\frac{1}{4}$ are in Fig. 4.

It will be seen from Fig. 4 that the stress at any point becomes in the neighbourhood of $\frac{b}{a}=2$, equal to what it would be for $\frac{b}{a}=\infty$. Again, if the principal stress in the plane of the plate is represented by Ap, its magnitude may be calculated by:

$$\left.\begin{aligned}
A_p &= \tfrac{1}{2}\left(\sigma_{xx}+\sigma_{yy}\right)\pm\sqrt{\tfrac{1}{4}\left(\sigma_{xx}-\sigma_{yy}\right)^2+\tau_{xy}^2}\\
&\text{and the angle } \theta \text{ it makes with X axis will be obviously represented by}\\
\tan 2\,\theta &= \frac{2\,\tau xy}{\sigma_{xx}-\sigma_{yy}}
\end{aligned}\right\} \quad (8)$$

The reaction at the fixed edge $y = \pm \frac{b}{2}$ may be obtained from the equation:

$$R = -\frac{E I}{1-\left(\frac{1}{m}\right)^2}\left(\frac{\partial^3 w}{\partial x^2 \partial y} + \frac{\partial^3 w}{\partial y^3}\right) \quad . \quad (9)$$

By putting $y = \pm \frac{b}{2}$ and expressing the results in terms of $\frac{b}{a}$ and p_a, the reaction at the middle point of edge and at the corner, which may be considered as the limit, are as represented in Fig. 5.

From this figure, it is important to note that the reaction at the corner of the plate is in the opposite sense to that at the middle point of the edge; this, in fine, indicates an action of holding down the plate from lifting at the corners. It will also be noted that this reaction also approaches the case for $\frac{b}{a} = \infty$ in the neighbourhood of $\frac{b}{a} = 2$.

II. *Mathematical Solution* (2) (*Pigeaud's Method*).—In Mons. Pigeaud's solution, to which the author has drawn attention at the beginning of this paper, w is taken as

$$= W + \sum_{m=1}^{\infty} C_m w_m + \sum_{m=1}^{\infty} C_m' w_m' \quad . \quad (10)$$

in which, if W satisfies the equation:

$$\frac{1}{12}\frac{E t^3}{1-\left(\frac{1}{m}\right)^2}\left(\frac{\partial^4 W}{\partial x \phi} + 2\frac{\partial^4 W}{\partial x^2 \partial y^2} + \frac{\partial^4 W}{\partial y \phi}\right) = f(x_1 y) \quad (11)$$

and if w_m and w_m' are inserted for W in the above equation, w_m, w_m', will become zero at the edges forming the function $f(x\,y) = 0$, and by a proper adjustment of C_m, C_m', the inclination should also become zero.

Now in order to secure this result, we must take the X and Y axes as coincident with two edges, and from the equation:

$$W = \sum_{m=1}^{\infty}\sum_{n=1}^{\infty} A_{mn} \sin\frac{m\pi x}{a} \sin\frac{n\pi y}{b}$$

$$(m, n \text{ . odd number}) \quad (12)$$

W is calculated, determining A_{mn} individually by a similar method to that already described. It is then only necessary to add w_m, w_m', to eliminate the inclination at edges of W.

Where w_m, w_m', are functions of plane strain and are generally written in the following forms:*

$$\left.\begin{aligned} w_m &= \phi(y)\sin\frac{m\pi x}{a},\ \phi(y) = y\left[e^{\frac{m\pi y'}{a}} - e^{-\frac{m\pi y'}{a}}\right] \\ &\quad + y\left[e^{\frac{m\pi y}{a}} - e^{-\frac{m\pi y}{a}}\right],\ \text{where } b - y = y' \\ w_m' &= \phi(x)\sin\frac{m'\pi y}{b},\ \phi(x) = x\left[e^{\frac{m'\pi y'}{b}} - e^{-\frac{m'\pi x'}{b}}\right] \\ &\quad + x'\left[e^{\frac{m'\pi x}{b}} - e^{-\frac{m'\pi x}{b}}\right],\ \text{where } a - x = x' \end{aligned}\right\} \quad (13)$$

Thus w_m, w_m', satisfy the differential equation (1), and at the same time are zero at the edges of the plate.

It is too tedious to take numerous values of w_m, w_m', so the author has accordingly calculated only the case of w_1, w_1'; even then the work was onerous.

Now, if we put

$$w = W + c_1 w_1 + c_1' w_1'$$

and arrange that the inclinations at the middle points of the long and short sides become zero, we see that the inclination at any point of the edges becomes negligibly small, as is shown in the Fig. 1.

Now, following the same method, the author has taken out the central deflections, stresses and reactions at the fixed edges for various values of $\frac{b}{a}$, and these are shown in the Fig. 2, Fig. 4 and Fig. 5. On referring to these figures it is not difficult to judge that the results are very near to those obtained by the author's method. It will be noted that in the Fig. 6, the range of deflections for the case of $\frac{b}{a} = 2$ is also shown.

In addition, the results obtained from the Grashof's empirical or, rather, hypothetical formula, are shown in the Fig. 2 and Fig. 4. These are based on rough reasoning, and the comparison made in Fig. 4 shows that they are not accurate.

III. *Experiments.*—The author's first attempt was to verify his theory by experiments. Experiments of this nature had already been carried out by Herr Bach, by the German Navy, and by Mr. Montgomerie, and one research carried out by the latter must be acknowledged as made with great care, yet there are some doubtful points in the deflections and stresses determined from the experimental results.

Mr. Montgomerie's experiments were made by applying water pressure on a steel plate held in an iron frame. It is obvious, therefore, that the frame was also strained by the water pressure. Moreover, a relatively high water pressure is required to deform a steel plate, thus increasing the difficulty and hence with such an arrangement it cannot be expected that the true values are reached, however minute the care taken. In examining Mr. Montgomerie's results it will be noted that the central deflection was greater when the thickness of plate was increased and greater water pressure applied.

The author's experiments were made on a celluloid plate, 48 cm. by 30 cm. by 0·407 cm., as suggested by Professor Suyehiro, and the frame for holding the plate was made of steel plates as shown in Fig. 7. The elastic modulus of celluloid being very low compared with that of steel, accurate elastic deformations could be easily recorded.

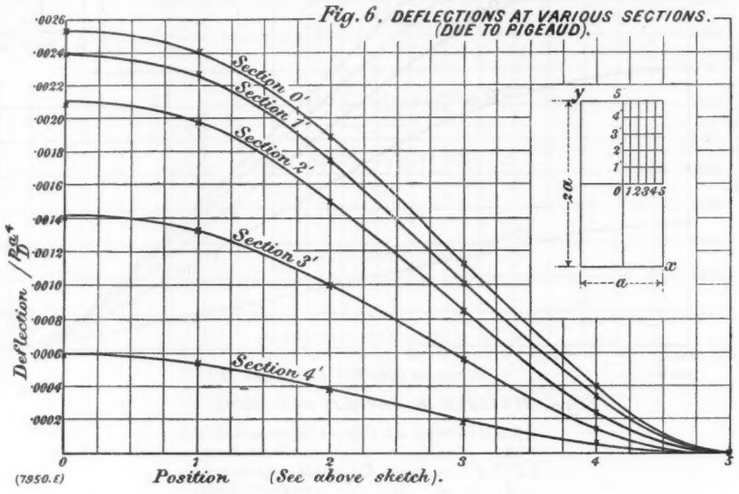
The frame was constructed of two steel plates, each 1 cm. in thickness, one forming the top part and another the bottom part of the frame, the bottom plate was finished perfectly flat and with a smooth surface, whilst the top plate was fitted with wedge-shaped lip around the rectangular opening of the plate, and the celluloid plate was inserted between these two plates.

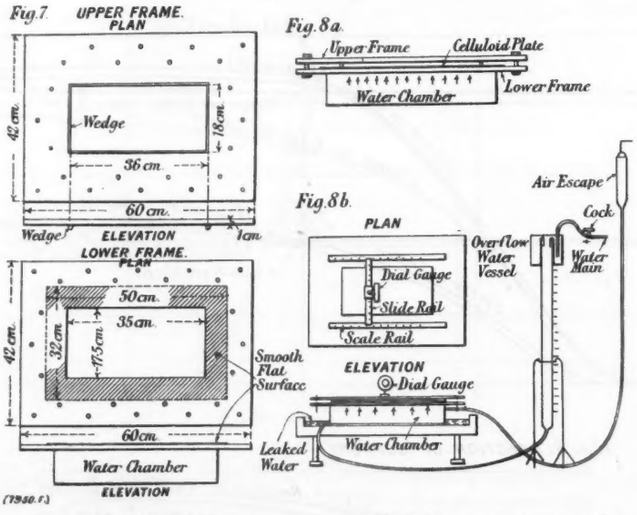
water pressure was observed by a dial gauge, the unevenness in the surface of the plate, however minute, being carefully observed before and after the experiment (that is to say, when there was no water pressure), and the relative deflection was estimated from these readings.

As this dial gauge had a scale of $\frac{1}{100}$ mm., it was not difficult to read to $\frac{1}{1000}$ mm.

The dial gauge was placed on a slide rail which bridged and rested on a set of scale rails placed at right angles to it, thus it was possible to observe the deflections at all X Y co-ordinates.

Young's modulus for the celluloid plate was determined, as the result of tests on an Olsen testing machine, to be E = 21,900 kg./cm., and Poisson's ratio was first calculated from the modulus of rigidity obtained by the torsional vibration of a rectangular bar. However, finding this torsional vibration method not quite reliable itself, the ratio was also measured directly by fitting two





If the water pressure be applied from below, the "clamping" at the edges will be exceedingly good. The arrangement is shown in Figs. 7 and 8. The degree of tightness of the holding-down bolts in the frame depended entirely upon hand adjustment, however, this operation was very much simplified by a fortunate fact that any bending of frame caused a leakage of water, both when the amount of "clamping" was too small and also when it was in excess, with the result that the proper "clamping" could only be realised within a very small range, and it should also be noted that the deflection did not change for a considerable range either side of this limit.

The water pressure was applied by the arrangement shown in Fig. 8. The cock from the water main was kept open just sufficient to make good the leakage of water from the corners of the water chamber, and although this small constant feed from the water main would in no way affect the experiments, the precaution has been taken to eliminate any impulsive force of water by receiving the water from the main first into the bottom of the water vessel as shown in the sketch. As the water rises up in the vessel, part of it is discharged as overflow and part of it enters the vertical tube. An air pipe was also fitted to the water chamber to allow the free escape of air.

The deflection of the celluloid plate caused by the sets of Marten's extensometers crosswise on the celluloid plate, and the result thus obtained was $\frac{1}{m} = 0{\cdot}3$.

The celluloid plate was 0·407 cm. in thickness, and its effective sides were 18 cm. by 36 cm. The water pressure applied was of two intensities, viz., $\frac{39}{1000}$ kg. per sq. cm. and $\frac{66}{1000}$ kg. per sq. cm.

Even with the greater of these two pressures, the deflection was only about 1·5 mm., and may be regarded as small in relation to the thickness; therefore it could be used with safety for comparison with the mathematical solution.

The extent of the deflection was expressed in terms of $\frac{p\,a^4}{D}$ from the mean of about five experimental results, and is shown in Fig. 9, and the deflection at the centre is also shown in Fig. 2 for purposes of comparison.

It is quite possible to determine the strain directly and graphically from this elastic curve, but fearing the calculation might be somewhat ambiguous, the author assumed lines of curvature to be in the directions of length and breadth at the vicinity of the centre of plate,

* Inglis, "Two-Dimensional Stresses in Rectangular Plates (Engineering, October 7, 1921).

and also at the middle of long edge, and each to be represented by the equation:

$$y = a x^2 + b x^4.$$

By taking five or six points for each case, and fixing the coefficients a, b, by the method of least squares, and differentiating it twice, the normal stress was calculated by the equation (7).

The result is shown by points A and B, in Fig. 4, and it will be seen that they are sufficiently near to the theoretical deductions. Fig. 10 represents the elastic curve along the short centre line obtained by the author's theory, Mons. Pigeaud's method, and by the author's experiments. It will be observed that they are sufficiently close to each other, and that the curves are of very similar nature.

Fig. 9. **DEFLECTIONS FOUND BY EXPERIMENT.**

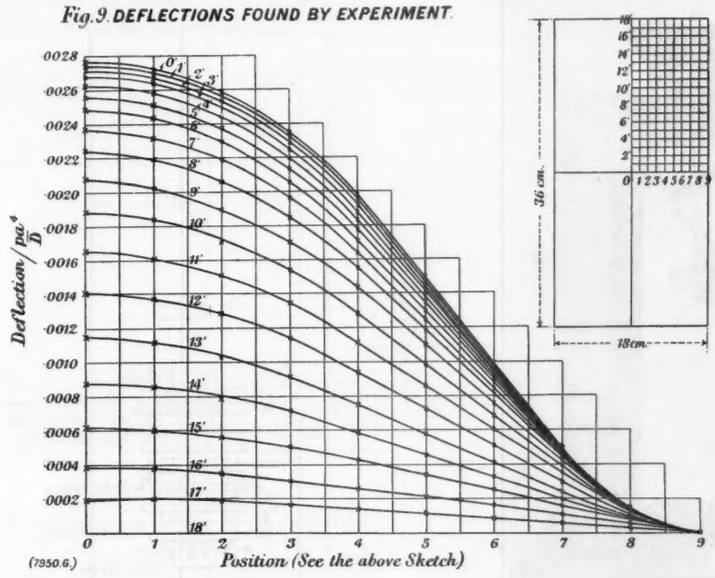
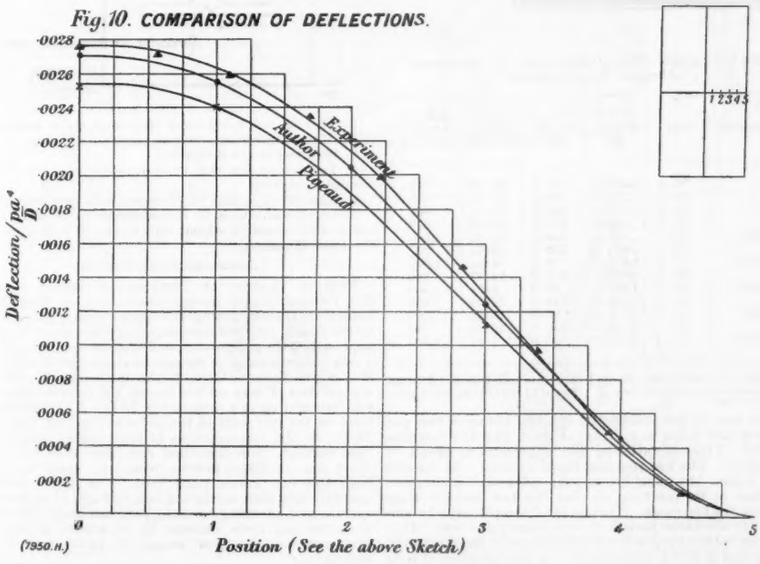


Fig. 10. **COMPARISON OF DEFLECTIONS.**



The figures given for the author's observation are those which are worked out independently of the E and $\frac{1}{m}$ peculiar to celluloid, but adopting the values of E and $\frac{1}{m}$ used by Dr. Montgomerie in his experiments.

With regard to Dr. Montgomerie's experiments, the deflections are shown in terms of $\frac{p a^4}{D}$ in Fig. 2, and the stresses in terms of $\frac{p h a^2}{I}$ in Fig. 4. It should be noted that in this case the deduction of the stress at the centre as an absolute value from Dr. Montgomerie's results becomes troublesome, and hence his results are plotted in without adjustment. (See Table in Col. 3.)

IV. *Conclusion.*—Whether deflections, stresses or reactions are considered, it is obvious that the values become close to those corresponding to $\frac{b}{a} = \infty$ in the neighbourhood of $\frac{b}{a} = 2$. Moreover, both the mathematical solution and the experimental results show that the stress at the end of the short centre line is twice that of the stress at the middle of this line, and the fact that when $\frac{b}{a} = 2$ the stress is nearly the same as when the $\frac{b}{a} = \infty$, is further evidence that the stress at the end of the centre line becomes about twice that of the stress at the centre.

This can also be demonstrated from other considerations, that is to say, for the case of square or when $\frac{b}{a} = 1$. Whether it is dealt with by the author's solution or by Pigeaud's method, we shall have an almost correct solution, and in this case, the stress at edge is twice as much as the stress at centre, and it is also when $\frac{b}{a} = \infty$. Therefore it will not be difficult to judge that it will also be about twice for intermediate ratios.

Hence it will not be perhaps unreasonable to express some doubt concerning Dr. Montgomerie's experiments, which indicated that the stress at the centre was almost as great as the stress at middle of the edge. On the contrary, the data* of the experiments carried out by the German Navy giving the stress at the edge of the plate as about twice that at centre, seem quite reasonable. In this connection the author may be permitted to remark that Dr. Montgomerie's experiments, in which a large steel plate was used as a test-piece, might have revealed peculiar phenomena.

Further, the fact that the reaction at clamped edges changes sign in the vicinity of the corners is worthy of consideration as an actual occurrence.

* Pietzker, "Festigkeit der Schiffe."

Table showing the Figures Directly Compared with the Results of Dr. Montgomerie's Experiments:—

Pressure	10 lb. per sq. in.	20 lb. per sq. in.	30 lb. per sq. in.	40 lb. per sq. in.
Thickness of plate ..	¼ in.	¼ in.	¼ in.	¼ in.
Central deflection:	in.	in.	in.	in.
Montgomerie	0·2035	0·163	0·0896	0·0410
Author's theory ..	0·205	0·121	0·0767	0·0304
Pigeaud's theory ..	0·192	0·113	0·0718	0·0284
Author's observation ..	0·210	0·124	0·0785	0·0312
Stress at centre:	tons per sq. in.	tons per sq. in.	tons per sq. in.	tons per sq. in.
Montgomerie	11·2 (1)	10·0 (2)	9·1 (3)	5·8 (4)
Author's theory ..	10·0	8·9	7·5	4·5
Pigeaud's theory ..	10·3	9·2	7·75	4·65
Author's observation ..	10·0	8·9	7·5	4·5
Stress on edge:	tons per sq. in.	tons per sq. in.	tons per sq. in.	tons per sq. in.
Montgomerie	12·2 (1′)	9·9 (2′)	8·2 (3′)	5·1 (4′)
Author's theory ..	21·6	19·2	16·2	9·7
Stress at the end of short centre line:				
Pigeaud's theory ..	22·1	19·6	16·6	9·9
Author's observation ..	24·4	21·6	18·3	10·9

The author must express his indebtedness to Mons. Pigeaud's work for confirming his own theory on this subject, and also to Professor Suyehiro for valuable advice and suggestions, and would at the same time add his thanks to Mr. Sato and Mr. Takehara, both of the Naval Architectural Laboratory, Imperial University, Tokyo, who assisted him in preparing this paper.

IMPERIAL AIRSHIP SCHEME.—The provision of an Imperial airship service has now received approval in principle, and a new step has been made towards the realisation of a rapid means of transit to outlying parts of the Empire. In the scheme of Government assistance, proposed by Commander Burney, the State liability is limited in three stages by the results achieved. The subsidy of 400,000*l.* a year is to be payable for seven years, but the second, third and fourth years' grants are dependent on the achievement of flight to India in 100 hours' running time, and the later payments are only to be made if the company maintains a weekly service to India. At the end of the seven years, the subsidies are repayable out of half the profits in excess of 10 per cent. When the scheme is completed there will be a bi-weekly service to India with six airships in commission. The promoters on the signing of the agreement are to form a guarantee company with a capital of 600,000*l.*, which will form the airship company with an initial capital of 400,000*l.*, and the first subsidy payment is to be made by the Government on the incorporation of this company.

THE OPPAU EXPLOSION.—On September 21, 1921, at 7 a.m., the Oppau works of the Badische-Anilin und Sodafabrik were partly destroyed and several hundred people were killed. In November, 1921, H. Goebel, chief engineer of the works, and E. Probst, professor of engineering at Karlsruhe, opened an inquiry into the lessons to be drawn relating to the strength of the buildings destroyed and of the materials used; their report, a quarto volume of 42 pages, well illustrated, has been published under the title "Die Lehren der Explosionskatastrophe in Oppau für das Bauwesen" (Berlin: Julius Springer; price 5*s.* net). The cause of the explosion is not referred to; secondary explosions are not mentioned. It is believed that the double salt of ammonium nitrate and sulphate (manure), stored in a large silo, had become so hard that it had to be blasted for removal. This was considered safe, but it exploded during blasting. The silo in question was situated at the southern end of the large premises; it was a building, 60 m. by 31 m., 19 m. high, of iron and brickwork with a wooden roof. That building and its concrete base disappeared completely, leaving a hole, 10 m. deep, surrounded by a fairly regular wall of débris, 115 m. by 75 m. Iron masses of 1 ton weight were projected in all directions to distances of 400 m.; most of the brickwork and concrete was broken up. The wooden structures of the plant, some remote from the source, were destroyed; there was no evidence of earth tremors, but oscillations made some walls and structures topple over towards the source. Most of the buildings were iron and ferro-concrete; the concrete was everywhere much cracked and joints were opened. Hooked bars in the ferro-concrete proved stronger than stirrups; some concrete bases were bodily lifted up. Near the source everything was destroyed; some ferro-concrete buildings, remote and in apparently sheltered positions, also succumbed. Rivet heads were wrenched off without indicating extension, which was marked in many threaded bolts. Much of the damage was due to collapsing roofs and girders. Of the two ferro-concrete chimneys, 95 m. high, of the boiler-house, one remained standing, the other collapsed; the wall thickness of the latter was uniform in the upper portion, whilst the wall thickness of the former decreased in steps. The full bowl-shaped liquid tanks suffered little; empty tanks and gasholders suffered more. Röntgen examination did not give any conclusive evidence of any transformation of the steel owing to excessive stress. The iron structures were more easily taken down, but less easily renewed, than the ferro-concrete structures.

DETERMINING THE RESISTANCE OF RUBBER PRODUCTS TO ABRASION.*

An Apparatus and Method for Determination of Resistance to Abrasion of Rubber Products.

By W. W. Evans.

Rubber, in service, is nearly always subjected to some sort of abrasion—tyres, belts, boots and shoes, hose, &c., all must resist abrasion—and in many cases resistance to abrasion determines the life of the article. It is important therefore, that the manufacturer should know accurately the relative abrasion resisting properties of different compositions, and it is very desirable that these properties should be measured in the laboratory. It is not surprising then that for years persistent attempts have been made to develop a machine for this purpose. Abrasion-testing machines have been built in a variety of forms, but, in general, the sample is subjected to the action of a revolving abrasion wheel or disc. One of the objections to this type of machine is the difficulty of maintaining the surface of the abrasion wheel. The surface of the wheel or disc quickly becomes clogged with the compound under test, which changes the rate of abrasion. This difficulty has been overcome by two machines using this system, namely, that developed by the United States Bureau of Standards and the one used by the New Jersey Zinc Company. Comparative tests have been made between the latter machine and the one described in this paper, and it has been found that similar results can be obtained. The machine described in this paper, developed by Mr. J. C. Sproull and co-workers in the testing laboratories of the B. F. Goodrich Company, is of a different type. The machine (Fig. 1) consists essentially of a train of 10 identical spur gears all in mesh and arranged in circular form in a horizontal plane. The shafts of alternate gears, five in all, extend vertically downward, so that the machine somewhat resembles a multiple spindle drill press. Fixtures carrying the test samples are attached to the bottom of the spindles, and are "buried" in loose abrasive material contained in cans as shown.

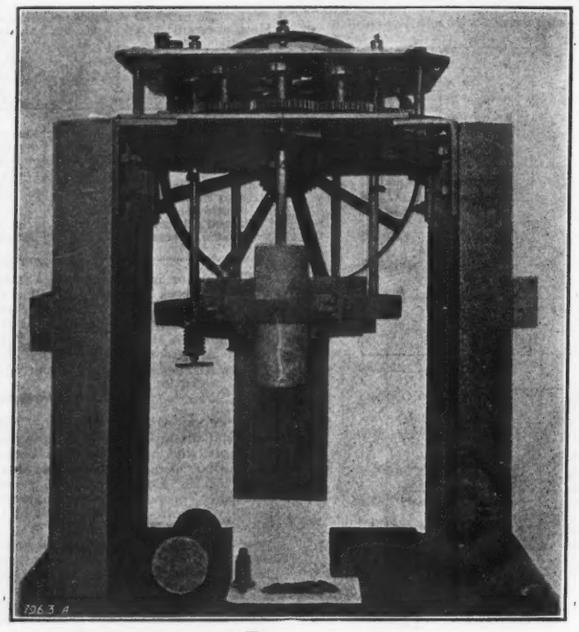


Fig. 1.

Detailed Description of Apparatus.—The body of the mandrel (Fig. 2) is 1 in. in diameter and 2⅞ in. long overall. This will take five samples of rubber when assembled for test. The mandrel is designed to be inverted, thus affording an equalised static pressure on all samples for the total test period. A small propeller arrangement has been made which is attached to the bottom of the mandrel, keeping the abrasive stirred up from the bottom of the can preventing any tendency towards congestion of abrasive. The spacing rings used between the samples are $\frac{5}{16}$ in. wide, 1¼ in. in outside diameter and 1 in. in inside diameter. The guard rings placed at either end of the mandrel are 1⅛ in. in outside diameter, 1 in. in inside diameter and ¼ in. wide. The abrasive container is a can 3 in. in inside diameter and 9 in. long. This shape has been chosen so as to reduce the amount of abrasive required to a minimum and yet afford a static head of about 5 in. above the top of the mandrel. A 20-mesh screen is soldered to the bottom of the container, which permits the abrasive dust to separate out. As an abrasive we have found that a carborundum grain between No. 6 and No. 8 mesh is most desirable. Crushed quartz of several varieties, steel grit, sand and alundum have been tried, but none are as satisfactory as the carborundum grain. In fact, we have found that steel grit and sand have very little abrasive action on rubber in such a test. The carborundum grain may be used a number of times by re-screening. Test samples are cut from sheets $\frac{5}{32}$ in. thick with a die 1 in. in inside diameter and 1¾ in. in outside diameter. Samples fit on a mandrel, the body of which is 1 in. in diameter and the rubber is not under tension when tested. We have followed the procedure of placing the standard compound in the centre and two experimental samples on either side.

Method of Test.—For one mandrel, five test rings are prepared and weighed, and placed on the mandrel. As indicated above, four of these are of the unknown compositions and one standard. The mandrel is fastened to the end of the rotating shaft, the abrasive can put in place and filled to the proper level, and the machine started. This operates at the approximate speed of 130 r.p.m. The test requires about 8 hours. At the end of 4 hours, the machine is stopped and the mandrel reversed in its position, so that the two bottom rings are now the top rings. This gives all samples equal static head for the same period of time during the test. It is also desirable to replace the abrasive with fresh material at the end of this 4-hour period. A typical series of tests is recorded in Table I.

Table I.—*Sample Test Calculation of Resistance to Abrasion Determination.*

Compound.	Can.	Initial Weight, Mg.	Loss in Weight, Mg.	Loss in Weight, per Cent.	Index of Abrasive Resistance
A	No. 1	2,481·0	531·0	21·37	759
B	No. 1	2,714·0	519·0	19·12	848
C	No. 1	2,707·0	509·0	18·81	862
D	No. 1	2,380·0	470·0	19·79	819
Standard ..	No. 1	2,780·0	450·0	16·22	1,000
E	No. 1	2,634·0	364·0	13·81	337
Standard ..	No. 1	1,676·0	78·0	4·66	1,000
E	No. 3	2,680·0	385·0	14·37	349
Standard ..	No. 3	1,637·0	82·0	5·01	1,000
F	No. 2	2,335·0	748·0	32·19	163
Standard ..	No. 2	1,670·0	88·0	5·25	1,000
F	No. 4	2,440·0	810·0	33·21	166
Standard ..	No. 4	1,630·0	90·0	5·52	1,000

Length of run, 8 hours; Room temperature, 86 deg. F.; Average temperature in cans, 150 deg. F.; Speed of mandrels, 130 r.p.m.

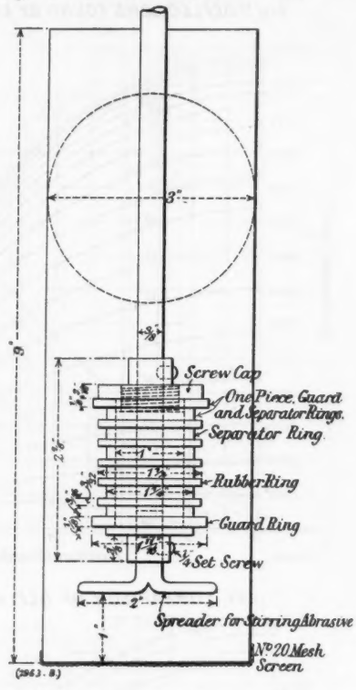
The samples are again weighed after the test, the loss determined and converted to an index number. The percentage loss of the standard compound is taken as 1,000. The percentage loss of each experimental compound on the mandrel is divided into the percentage loss of the standard compound and multiplied by 1,000. A compound with an index number of 1,100 is, accordingly, better than the standard compound in resisting abrasion and one with an index number of 900 is not as good as the standard. It is unnecessary to obtain the specific gravity or the volume loss of each compound, since the percentage loss in weight is the same as the percentage loss in volume. Experience indicates that it is necessary to wear away 15 per cent. to 20 per cent. of the original volume of the sample, in order to obtain consistent results.

One source of error is the difference in thickness of the test samples. Moulded sheets used for this purpose are found to vary from 0·080 in. to 0·120 in. in thickness. The total area of rubber exposed to the abrasive on a sample 0·080 in. thick is 1·114 sq. in., and that for a sample 0·120 in. thick is 1·135 sq. in. The difference is 0·021 sq. in. or 1·88 per cent. (based on thickness of 0·080 in.).

A test begun in one container should be completed in that container. Eccentricity of the shaft on which the mandrel is fastened will cause different degrees of wear in each container, assuming shafts and mandrels do not run perfectly true. Some advantages claimed for this abrasion-testing machine are as follows:—

1. It is reasonably consistent. When a spool is loaded with samples all cut from the same sheet of rubber, the results check very closely.
2. The test samples are small enough to be cut from many finished articles.

Fig. 2. SPECIMENS ASSEMBLED IN CAN



3. The volume worn away from any given sample has little, if any, influence upon an adjacent sample.
4. Stiffness is not a factor.
5. Tests may be run in a reasonable time without excessive heating.
6. The abrasive can be screened and used repeatedly.
7. Local variations of the abrasive material, such as occur with abrasive wheels and discs, do not occur with the loose abrasive.

Fender Chains at Panama.—A recent issue of *The Panama Canal Record* states that on May 25 the fender chains protecting the upper guard gates at the Gatun Locks prevented an accident when the S.S. Hoven approached the gates at a speed of about 4 m.p.h. through a misunderstanding of signals in the engine-room. The Hoven was about to tie up to the approach wall, but with a good deal of way on her struck the fender chains and was brought up in a distance of 50 ft. The difference in level on the two sides of the gates at the time was about 15 ft., so the consequences of their failure might have been serious. We described and illustrated the fender chain gear in Engineering when the canal was being built (see vol. xcviii, page 146). The gear consists of chains drawn taut across the lock in front of approaching vessels, and, on being run into, paid out gradually against a restraining force excited by hydraulic means. On this occasion the gear seems to have worked very successfully.

Coal Washing Tests at Seattle.—In the course of the coal-washing investigations being conducted by the Department of the Interior at the North-west Experiment Station of the Bureau of Mines, Seattle, Wash., a careful study has been made of the float-and-sink test as applied to fine sizes of coal. Methods and apparatus have been developed and successfully applied to coal ranging in size from 20-mesh to finer than 300-mesh. Briefly summarised, the methods and apparatus are as follow: The coal should be air-dried and tested with carbon tetrachloride mixed with benzene or bromoform, depending upon whether the desired specific gravity is above or below 1·60. Each test should be repeated until a complete separation is effected between the "float" and the "sink." The most suitable apparatus was found to be two-litre reagent bottles combined with a simple siphoning device for withdrawing the products of the test. The methods developed have been used in determining the proportions of free coal, bone, and refuse in representative samples of fine coal from the mines of Washington.

* Paper read at the twenty-sixth annual meeting of the American Society for Testing Materials, at Atlantic City, N.J., June 25 to 29, 1923.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACTS OF 1907 AND 1919.

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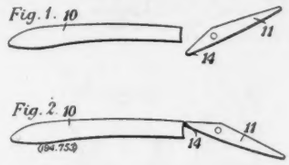
Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

AERONAUTICS.

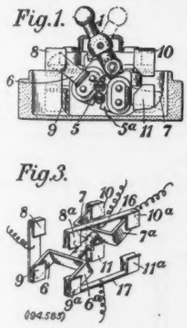
194,753. L. G. Frise, Westbury-on-Trym, Bristol, and The Bristol Aeroplane Company, Limited, Bristol. Control Surfaces. (4 *Figs.*) November 16, 1921.—The invention relates to control surfaces for aircraft of the type in which the movable aerofoil 11 is associated with a fixed aerofoil 10 situated immediately behind it in the line of flight and so arranged that in its neutral position it constitutes a continuation of the fixed aerofoil. According to the invention, the



combination of a fixed aerofoil 10 and an adjustable aerofoil 11 of the kind described is characterised by the fact that any upward movement of the trailing edge of the adjustable aerofoil 11 from its neutral position causes the leading edge 14 of the adjustable aerofoil to project downwards beyond the contour of the fixed aerofoil 10, or opens a gap between the adjustable aerofoil and the fixed aerofoil, but movement downwards is possible without producing such projection or gap (Fig. 2). (*Sealed.*)

ELECTRICAL APPARATUS.

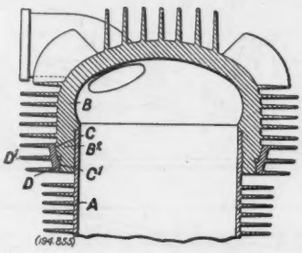
194,585. A. P. Lundberg, Holloway, G. C. Lundberg, Holloway, P. A. Lundberg, Holloway, and G. Pegg, Holloway. Electric Switches. (5 *Figs.*) April 26, 1922.—The invention has relation to electric switches of the tumbler type known as intermediate switches. 1 is the actuating lever. The contact member 5 is articulated to the lower end of the actuating lever 1 and is under the influence of a spring that provides a quick make and break action. The contact member 6 comprises two pairs of knife contacts 6, 6*a*, 7, 7*a*; the pair 6, 6*a* is integral, as is the pair 7, 7*a*, and the two pairs are insulated and mounted on the part 5*a* of the contact member 5. There are four pairs of fixed contacts 8, 8*a*, 9, 9*a*, 10, 10*a*, 11, 11*a*. The pairs of fixed contacts 8, 8*a*, 9, 9*a* are disposed the one above the other and positioned to co-operate with the knife contacts 6, 6*a*. The pairs of fixed contacts 10, 10*a*, 11, 11*a* are also disposed the one above



the other and positioned to co-operate with the knife contacts 7, 7*a*. The fixed contacts 8, 9 are carried by a terminal post 12 and are in electrical connection; the fixed contacts 10, 11 are carried by a terminal post 13 and are in electrical connection; the fixed contacts 8*a*, 9*a* are carried by a terminal post 14, the contact 9*a* being in electrical connection therewith and the contact 8*a* insulated therefrom; the fixed contacts 10*a*, 11*a* are carried by a terminal post 15, the contact 10*a* being in electrical connection therewith and the contact 11*a* insulated therefrom. The insulated contact 8*a* is electrically connected by a bonding member 16 with the contact 10*a*, and the contact 9*a* is electrically connected by a bonding member 17 with the insulated contact 11*a*. A, B, C, D are the wires connecting the intermediate switch with other intermediate switches, or with two two-way switches or with a two-way switch and an intermediate switch. (*Sealed.*)

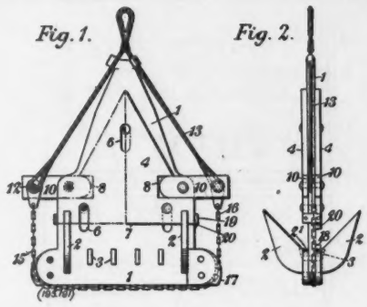
GAS ENGINES, PRODUCERS, HOLDERS, &c.

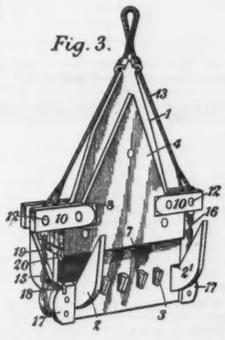
194,855. D. Napier and Son, Limited, Acton Vale, London, and G. S. Wilkinson, Acton Vale, London. Internal-Combustion Engines. (3 *Figs.*) January 19, 1922.—The invention relates to air-cooled cylinders of that type in which an open-ended cylinder A formed of steel has mounted on its end a head B constructed of aluminium. The locking of the head B on the cylinder A is effected as follows:—The exterior of the head flange B_2 which engages the end of the cylinder is formed conical at its upper end C, but for its remaining length it is formed parallel with the cylinder, the lower end of such portion being screw-threaded as at C^1. A ring D constructed of the same steel as the cylinder and conventently provided on its exterior with radiating fins D^1 is internally coned and threaded to engage the exterior of the head flange B_2. When this ring is in position and screwed up, the flange B_2 will be clamped or held between the ring D and the cylinder, and since both these parts are formed of metal having the same or substantially the same coefficient of expansion, the expansion of the interposed metal of the head will be controlled and a tight joint between the head and the cylinder maintained. (*Sealed.*)



LIFTING AND HAULING APPLIANCES.

195,191. F. H. Larnder, London. Grapnels. (4 *Figs.*) January 12, 1922.—The invention relates to grapnels for submarine cables which on grappling the cable cut it and grip one end only to bring it to the surface, these operations being brought about by the increased tension on the towing rope when the cable is grappled. Towards the lower edge of the bed plate and on each face thereof there are provided grappling hooks 2 and projecting ledges 3, the upper surfaces of these ledges and the bottom 21 of the hooks being in line and constituting a jaw. On each face of the bed plate there is mounted a sliding plate 4, these sliding plates being connected to each other and to the bed plate by rivets which pass through slots 6 in the bed plate. The lower edges 7 of the sliding plates constitute a jaw. The sliding plates are provided with recesses 8 into which project the rounded ends of lever arms 10 which are pivoted to the bed plate in pairs. The pair of lever arms at each edge of the bed plate is, moreover, connected together by rivets 12. A length of wire rope 13 is provided, the two ends of which are connected with the rivets 12, and the centre of which is formed into a loop, the rope passing on each edge of the bed plate through two eyes formed at the apex of the latter. 15 is a chain which is connected at its two ends with the two rivets 12 and passes round the bottom

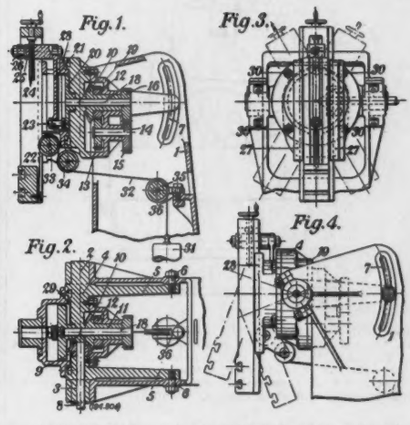




edge of the bed plate. One of the links of this chain, for example that shown at 16, is weaker than the rest of the chain, and is designed to break on a predetermined strain being applied to the towing cable. 17 are cheeks riveted on to the bed plate at the two bottom corners thereof and on each face, these cheeks serving the purpose of providing a support for the lower knife 18, and also serving to provide an easy bend for the cable when it is being lifted. 19 are steel bars, one of which is provided at each edge of the grapnel and attached to the edges of the sliding plates 4. One end of each of these bars is formed as a knife 20 adapted to co-operate with the knife 18 to cut the cable when gripped. When the cable is gripped, the prongs 2 lead it with certainty on to the lower jaw constituted by the bottom of the hooks and the top surfaces of the ledges 3. On continued movement of the towing ship the strain on the towing rope increases until the link 16 breaks, whereupon the outer ends of the lever arms 10 are pulled upwards, moving about their pivots, while their inner rounded ends, working in the slots 6 in the sliding plates, force the latter down upon the cable so as to grip it firmly and to cut it away on one side of the grapnel. One end of the severed cable is thus firmly held between the jaws of the grapnel and can be raised to the surface. (*Sealed.*)

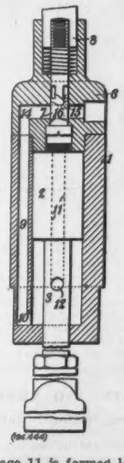
MACHINE AND OTHER TOOLS, SHAFTING, &c.

194,905. G. Birrell, Kirkcaldy, and J. Birrell, Kirkcaldy. Slotting Machines. (4 *Figs.*) February 20, 1922.—The invention relates to slotting machines. According to this invention, for the purpose of varying the path of movement of the cutting tool towards and away from the worktable, the toolholder is carried in a frame, mounted on a pivot, the tool-holder also being adjustable about an axis which is at right angles to the pivotal axis of the frame and to the plane of movement of the tool-holder. Means are provided to secure the frame in a desired position. 1 is the main frame of the machine within which is mounted on the trunnions 2, 3, a frame 4 with its axis horizontal. The frame 4 has projecting behind it arms 5, 5, which are secured to the frame 1 in any desired position by bolts 6, 6 passing through slots 7, 7. The trunnion 3 is hollow and constitutes a bearing for the driving shaft 8 on to which is keyed a bevel wheel 9, which meshes with a bevel wheel 10 on a hollow shaft 11. Keyed on the shaft 11 is a spur wheel 12 which meshes with a second spur wheel 13 keyed on a shaft 14, on which is also keyed an eccentric gear wheel 15 which meshes with a second eccentric gear wheel 16 keyed to a shaft 18 which runs within the hollow shaft 11. The axes of the shafts 18 and 11 cut the pivotal axis of the frame 4. The shaft 18 extends through the frame 4 and at its front end is keyed a crank disc 20, which



is connected by a connecting rod 21 to the tool holder 22. The height of the tool holder 22 is adjustable by the screw 24 which engages the block 25. The block may be locked in position by the plate 26. The tool holder 22 moves in guides 27 formed on a bracket 28 mounted so as to swivel about a horizontal axis in the frame 4 on a spigot 29. The axis of the bracket 28 is at right angles to, and cuts the axis of the frame 4. To the lower end of the tool holder 22 is attached a counterweight 31 by a wire rope 32 passing over pulleys 33, 34 and 35. The pulley 35 is mounted on a swing bracket 36. In use, the frame 4 may be arranged at an angle and secured by the bolts 6 so that the tool holder 22 will assume a sloping position as indicated in dotted lines in Fig. 4. By varying the position of the bracket 28 the tool holder may also be arranged to move at an angle across the face of the machine as indicated in dotted lines in Fig. 3. Thus, work may be machined at an angle, and as the axis of the driving mechanism coincides with the axis about which the frame is pivoted, the driving gear is always in mesh. (*Sealed.*)

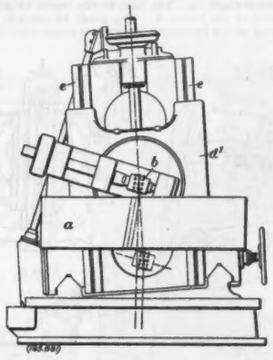
194,444. J. W. M. Hall, Dalmuir, and G. McIntosh, Glasgow. Pneumatic Caulking Tools. (1 *Fig.*) December 31, 1921.—The invention has reference to pneumatic caulking tools of the type in which a piston provided with a longitudinal passage and port operates within a cylinder also provided with a longitudinal passage and port. According to the invention, the pneumatic caulking tool comprises a cylinder 1 in which is located a piston 2 having a piston rod 3. The cylinder 1 is fitted with a cap 6 having a valve controlled air inlet passage 7 and a valve-operating and spring-controlled handle 8. 9 is an air passage in the wall of the cylinder extending from the air inlet passage 7 to the other end of the cylinder 1, with which it communicates



by a port 10. A passage 11 is formed longitudinally through the piston 2 and the piston rod 3, and has at its lower end a port 12. The air control valve consists of a rod 16 having a groove 15 and adapted to slide through the cap 6 and across the inlet passage 7. When the rod 16 is depressed by means of the handle 8 against the action of its spring, the groove 15 registers with the air passage 7 and permits the passage of air into the passage 9. When the handle 8 is released, the spring causes the rod 16 to close the passage 7. The air passes down the passage 9 into the cylinder 1 below the piston 2, which is driven towards the cap 6. As soon as the port 12 in the piston rod 3 communicates with the interior of the cylinder 1, the air below the piston passes through the passage 11 to the other side thereof. As the area of the upper side of the piston 2 is greater than the

area of the piston rod side of the piston, the piston moves forward to deliver the blow. As the blow is delivered the port 12 communicates with the atmosphere and releases the pressure behind the piston which returns under the pressure of the air entering the closed end of the cylinder 1. As soon as the port 12 is closed to the atmosphere and opened to the cylinder the operation is repeated and a second blow is given and so on; the action is repeated as long as the air valve 16 is held open by the operator. (*Sealed.*)

195,681. David Brown and Sons (Huddersfield), Limited, Lockwood, Huddersfield, and H. E. Kitchen, Lockwood, Huddersfield, and F. W. Shaw, Lockwood, Huddersfield. Hobbing Machines. (1 *Fig.*) November 5, 1921.—The invention relates to machines for hobbing cylindrical gear wheels of the type in which axial movement is given to the hob as it is fed



across the peripheral face of the blank. According to the invention, the axial movement is attained by arranging the guides *e*, *e* on which the slide d^1 carrying the hob *b* traverses, at an angle to the axis of the blank *a*, so that as the hob is fed through the blank it is also compelled or constrained to move endwise or tangentially in relation thereto. (*Sealed.*)

MINING, METALLURGY AND METAL-WORKING.

195,695. H. P. Hoyle, Durham, and The Grange Iron Company, Limited, Durham. Screening Apparatus. (9 *Figs.*) December 6, 1921.—The invention relates to screening apparatus. According to the invention, the screening surface *a* has imparted to it a vibratory movement by arms *t* engaging the screening surface and actuated by eccentrics *q* on a shaft *p*. Preferably the eccentric portions *q* of the shaft are formed with their axes in line, which line passes through the centre point of the axes of the portion of the shaft between the eccentric portions. The arms *t* are mounted perpendicularly to the common axis of the eccentric portions and at each revolution of the shaft *p* the

Fig. 1.

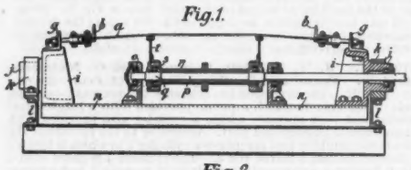
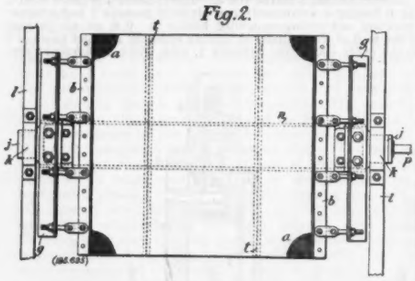


Fig. 2.



screening surface *a* receives an up and down movement combined with a cross-wise movement. The eccentrics *q* are preferably set at an angle at 180 deg. to each other. In one embodiment of the invention, the shaft *p* is mounted in bearings *o* below the screening surface and on the eccentric portions *q* of the shaft are other bearings *s*, mounted upon which is a hollow sleeve *r* carrying the arms *t*. The screening surface *a* is secured to side clamping bars *b*, which are secured to side arms *g* bolted to supports *i* having trunnions *j* held in clamps *k* secured to the fixed frame *l* by bolts. The supports are connected together by bars *n* upon which the bearings of the shaft *p* are mounted. (*Sealed.*)

RAILWAYS AND TRAMWAYS.

194,834. D. W. Jones, Bedford. Railway Wagon Brakes. (4 *Figs.*) March 2, 1922.—According to the invention, a short operating shaft 1 is mounted in bearings supported below the frame of the wagon by means of brackets 4 secured at each side thereof. The short shaft 1 is situated between the two sets of wheels upon which the brake shoes act, and a lever is mounted on the shaft 1. Upon the shaft 1 is fixed a double-ended link or crank 10 having bearing pins projecting at both ends thereof. Notched rods 12, the notches of which engage with the bearing pins at the two ends of the link 10, are connected at their other ends, one to each of the two brake blocks operating on the wheels between which the transverse shaft 1 is mounted. The mechanism is duplicated on the other side the vehicle to operate the brake blocks acting on the pair of wheels at the other side of the vehicle. When one of the operating levers 5 is actuated it will rotate the short shaft 1 and with it the double-ended links 10 mounted thereon. The bearing pins in the ends of these double-ended links 10 being in engagement with the notches in the connecting rods 12, will cause the brake shoes to be applied to the wheels. If a considerable amount of wear should take place, then when the operating lever is returned to its original

Fig. 1.

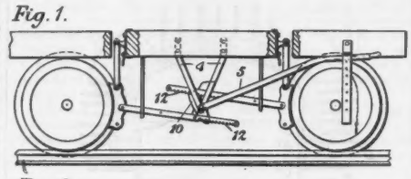
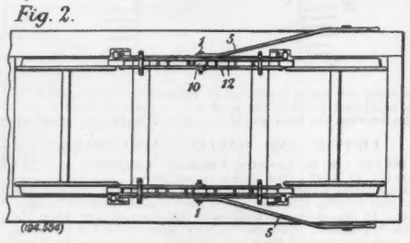


Fig. 2.



position, the bearing pins in the ends of the double-ended links 10 will ride over the notched teeth in the connecting rods and will become engaged in another set of notches. This will ensure the correct application of the brakes to the full extent at the next operation of the brake lever. (*Sealed.*)

STEAM ENGINES, BOILERS, EVAPORATORS, &c.

193,116. A. W. R. Edwards, Chorlton-cum-Hardy, Manchester. Water Cooling Towers. (2 *Figs.*) November 12, 1921.—The invention relates to water-cooling towers of the type used for reducing the temperature of condenser cooling water of engines or from other sources prior to its passing back into the storage reservoir. In carrying out the invention, there is located below and at right angles to the usual secondary troughs or conduits *a* from which the water escapes in small jets, a series of horizontal laths or bars *c*, each having an inclined

Fig. 1.

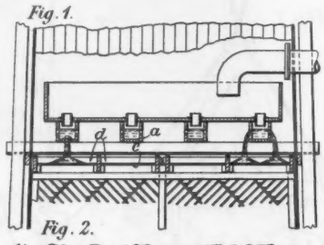
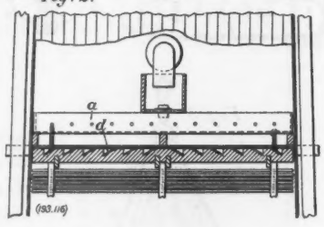


Fig. 2.



upper face *d* or faces. The inclined faces are each arranged at an angle designed to spread each jet of water fanwise, as shown in Fig. 1, from the point of contact of such jet with it, and so that the combined spread-out streams will fall off the lower edge or edges in a substantially continuous thin sheet throughout the full length of the inclined surface or surfaces, and thus be in a much better condition for further cooling by the usual devices located below them and, finally, fall into the cooling pond or reservoir. (*Sealed.*)

192,736. E. Wright, Seaforth, and G. Evans, Aintree, Liverpool. Liquid Fuel Burners. (2 *Figs.*) October 7, 1921.—The invention relates to liquid fuel burners of the type in which the liquid fuel is atomised by and mixed with a jet of steam. According to the invention, the steam jet issues in the form

Fig. 1.

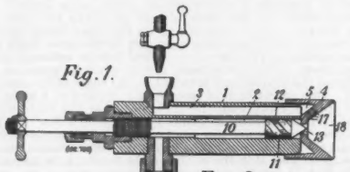
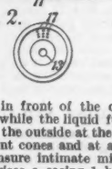
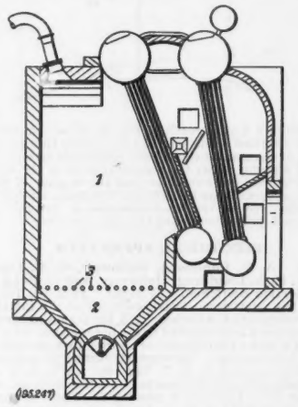


Fig. 2.



of a cone which converges at a point in front of the orifice of the steam passage and then diverges while the liquid fuel is adapted to impinge on the steam jet from the outside at the common apex of the convergent and divergent cones and at a considerable angle to the conical axis to ensure intimate mixture of the two elements. The burner comprises a casing 1 having a central steam passage 2, with a liquid fuel passage 3 arranged in its upper portions. These passages open into a nozzle 4 in the form of an outwardly-tapering chamber 18, in which the mixing and atomisation of the fuel takes place. 5 is an annular chamber in the nozzle into which the fuel passage 3 opens. The steam is led to the passage 2 through a pipe 8. Inside the steam passage 2 is a valve spindle 10, with a cylindrical-conically ended valve 11 at the end adjacent the nozzle 4. Grooves 12 are formed on the valve 11 on its cylindrical portion, which is made a sliding fit inside the passage 2. The conical portion of the valve closes on to a knife-edge seating 13 formed in the nozzle 4. The liquid fuel is introduced into the atomising space through a number of small orifices 17 which are arranged in the upper portion only of the nozzle 4 and above the point at which the steam jet converges into the common apex, and then diverges. By causing the liquid fuel to flow through the annular chamber 5 in the nozzle 4, the fuel is preheated before being mixed with the steam, so that it issues at a relatively high temperature from the orifices 17, and is therefore more easily atomised. On account of the conical form of the valve 11 and in view of the knife-edged formation of the valve seating 13 the steam jet issues in a sharply-defined cone whose apex is a little in front of the apex of the conical valve 11 after which it diffuses in the form of a reversed cone and finally breaks up into a conical spray. At the same time the liquid fuel flows through the orifices 17 and impinges on the steam jet at its narrowest portion, so that as the jet emerges into a spray the liquid fuel is intimately mixed with the steam. As the nozzle 4 becomes more heated after the burner has been in operation the liquid fuel will emerge in an early vapourised condition so that the mixing of the fuel and steam becomes more intimate. (*Sealed.*)

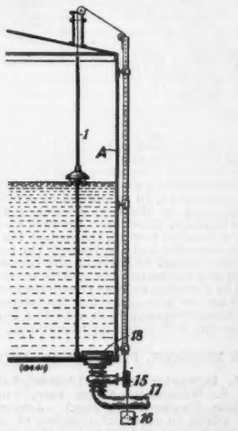
195,247. J. S. Atkinson, Westminster, and The Powdered Fuel Plant Company, Limited, Westminster. Powdered Fuel Furnaces. (3 *Figs.*) March 2, 1922.—According to the invention, the ash pit 2 of a combustion chamber 1 in which powdered fuel is used as the combustible is provided with means by which a film or body of air, steam or water is formed across



the lower part of the combustion space and above the ash pit, these means comprising a series of pipes or ducts 3 in connection with a supply of air under pressure, steam or water, and having emission apertures through which the air, steam or water flows and is directed to form a film or body through which the residues pass and to the cooling action of which they are subjected. (*Sealed.*)

MISCELLANEOUS.

194,411. V. Sevian. Kilburn. Protecting Inflammable Liquids from Fire. (7 *Figs.*) December 13, 1921.—The invention relates to means for the protection of inflammable liquids, such as petrol, stored in bulk from fire and for the extinguishing of fires in such liquids. Means for the purpose specified, according to the invention, comprises the combination of a main tank or other bulk storage receptacle A, a subsidiary reservoir or receptacle (not shown), a connection 17 between the tank A and the subsidiary reservoir, a primary closure in the



connection 17 comprising a rotary valve 15 that is normally held closed against the action of an operating weight 16 by a fusible member comprising a number of parallel wires spaced apart, anchored at one end and in connection at the other end with the operating weight 16, and a secondary closure separate from and wholly independent of the primary closure 1 comprising a drop valve 18 normally held open by a fusible member and adapted to function after the primary closure. (*Accepted March 21, 1923.*)